2008 – Current Model Years

Service and Maintenance Manual

Rev.C

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Chapter 1: Introduction

1.1 About the Manual

This service manual is designed to familiarize you with the safe and proper maintenance and service procedures for your *e-ride* vehicle. It will help you learn about standard maintenance and repair procedures. It will also give you important information about the vehicle and problem diagnosis as well as obtaining the optimal performance from your vehicle. **This manual is applicable to the two e-ride Industries models: the two passenger EXV2 Patriot and the four passenger EXV4.**

1.2 Vehicle Specifications

1.2.1 General Specifications

Curb Weight	2,150 pounds (Varies)
GVWR	3,000 pounds
Width	60 inches
Height	70 inches
Drive System Voltage	72 volt
Batteries	8 volt lead acid – qty. 9
Drive Axle	Gear reduced direct drive (12.49:1 ratio)
Motor	72 volt DC separately excited (optional 72 volt AC)
Top Speed	25 miles per hour
Tires	215/75R14 street rated
Brakes	Hydraulic four wheel disc drum park brake
Steering	Rack & pinion
Chassis	Riveted aluminum
Bumpers	Steel front and rear
Suspension	Independent front suspension, leaf spring solid axle in rear
Speed Controller	72 volt Curtis 1244 with regenerative braking (optional 72 volt Curtis 1238 AC)
Charger	See Electrical and Charger Section
Charge Time	See Electrical and Charger Section
Charging Energy Requirements	See Electrical and Charger Section
Lights	Headlights w/bright, taillights, turn signals, hazard lights, and brake lights

1.2.2 EXV2 Patriot Only Model Specifications

Length	155 inches
Flatbed Bed Size	66 inches x 59 inches

1.2.3 EXV4 Only Model Specifications

Length	145 inches
Cargo Box Size	28 inches x 55 inches

Chapter 2: Routine Maintenance

e-ride Routine Maintenance Table			
No.	Maintenance Task	Monthly	Yearly
1	Fill Battery Water (Flooded Only)	x	
2	Battery Visual Inspection	x	
3	Check Tire Pressure	x	
4	Check Tire Wear		x
5	Rotate Tires		x
6	Check Parking Brake Adjustment		x
7	Grease Ball Joints		x
8	Lubricate Door Latches		x
9	Check Brake Fluid Level		x

Table 1: Maintenance Table

2.1 Battery Water Filling

If your vehicle is equipped with flooded batteries the battery cells need to be checked and filled on a routine basis. It is recommended that this be done monthly. Perform this in a well-ventilated area that is dry and well lit.

To fill the batteries:

1. Fill the provided tank with distilled or de-mineralized water.
2. Open the hood and locate the battery water fill hose. It has a red cap on the hose and is strapped to the wiring harness. Take the cap off the connector.
3. Place the supplied 2 ½ gallon tank on the roof of the vehicle with the tank fill hose hanging over the front of the windshield.
4. Connect the tank female connector to the male connector from the vehicle. To connect them just press the two connectors together until it clicks.
5. Keep filling the water bottle as necessary to continue filling the batteries (it fills the best with a full tank). The wheel in the tank fill hose will continue to spin fast as long as water is going into the batteries. Once the wheel has slowed down or stopped, the batteries are full of water. Disconnect the water bottle hose by pressing the button on the coupler and re-attach the battery pack fill hose to the vehicle with the cap in place.
6. Never leave the water tank hooked up to the vehicle unattended. Make sure to disconnect the hose immediately after the water flow wheel slows down to where you can see the whole propeller.

2.2 Battery Pack Visual Inspection

2.2.1 Battery Pack Access

****Important Safety Note:** Before removing any parts to access the batteries for inspection, disconnect the main battery disconnect located in the front passengers side wheel well. Always remember when inspecting the batteries, that the main battery disconnect only disconnects power to the vehicle and does not disconnect power from battery to battery.

Batteries can produce explosive gases which can cause personal injury. Therefore, do not allow flames or sparks to come near the battery. When working near the battery, always shield your face and protect your eyes. Always provide ventilation.

1. *Cab Compartment Battery Access*
   Remove the center arm rest pad and console. The park brake lever (if ratcheting handle type) will have to be in the engaged position so that the handle is raised in order to remove the center pad (and tunnel cover once the console is removed later). Disconnect the wiring harness plug from the console. Then the console can be slid back slightly, lifted up and removed. The heater tube hoses might have to be removed from the console if the vehicle is equipped with a heater. The center aluminum tunnel cover, which is attached by Velcro, can then be lifted off.

2. *Flatbed Access Panel (EXV2 only)*
   On an EXV2, the cab access area only reaches a limited amount of the batteries, so there is another access point from the top of the flatbed. Remove the panel in this area by releasing the four quarter-turn fasteners that secure it. The batteries can all be removed through these access areas, but some of the following steps may have to be shuffled depending on what is easier for each person who attempts it.

2.2.2 Inspection Procedure

1. Make sure main battery disconnect has been shut off.
2. If your vehicle is equipped with flooded batteries inspect the fluid level in each cell by looking to see how high the white float is sitting in each cell cap. If a battery cell is full of water the white float indicator will be at the top of the fill cap. If the battery cell needs water the white float indicator will be recessed into the fill cap. Before checking the level of these floats, rock the vehicle slightly to free any stuck floats.
3. Inspect for any loose connections by wiggling the top post battery cables where they clamp onto the top of the battery. If you find any signs of a loose cable connection, they must be tightened by a trained professional before the main battery disconnect is turned back on. *Note: The main battery disconnect does not disconnect power from battery to battery.
4. Inspect for any acid spills or corrosion to the battery posts or cables. If corrosion exists, the aluminum or metal components will turn white in color.

All acid or corrosive metals must be cleaned appropriately by a trained professional before the main battery disconnect is turned back on.

5. Replace all components back into the vehicle before turning the main battery disconnect back on.

2.3 Tire Inflation

Under-inflation increases tire flexing and can result in tire failure. Over-inflation causes a tire to be too stiff. Objects on the ground could puncture the tire more easily and tire failure could occur. Unequal tire pressure can cause steering problems and could also cause you to lose control of the vehicle. Take these steps set tire pressures:

1. Use an accurate tire pressure gauge.
2. Check the tire pressure when tires are cold, after the vehicle has been parked for over an hour or has been driven less than 3 miles.
3. Adjust the tire pressure according to the recommended specifications listed on the sidewall of the tires and on the VIN label on the driver's seat base (35 psi).

2.4 Tire Wear and Alignment

At least once a year, check your tire alignment to the specifications listed at the end of section 5.2. If your alignment is not correct, this could cause steering resistance and rolling resistance which would cause a decrease in the range and overall performance of the vehicle. This can also lead to uneven tire wear mostly seen on the front wheels. If there is a rear tire wear problem, this is probably due to major damage to one or more components in the rear suspension causing the misalignment of the rear wheels. An alignment check for the rear wheels is suggested along with the fronts.

Replace the tire when the tread depth is at or less than 2/32" of remaining tire depth. Replace only with the original tire size (P215/75R14). Tires smaller or larger than the original size may affect the accuracy of the speedometer, performance and life of the vehicle.

2.5 Tire Rotation

Because each of your vehicle's tires perform different jobs, they often wear differently. To make sure the tires wear evenly and last longer, rotate them on a regular basis. Rotation is suggested, at a minimum, on a yearly basis or about every 3000 miles, whichever comes first. See diagram for proper tire rotation.

Front of Vehicle

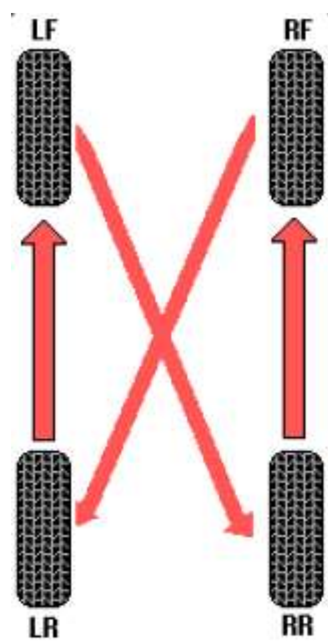


Figure 1:
Tire Rotation diagram

2.6 Parking Brake Adjustment

The parking brake is a manual, mechanical way of actuating the rear brakes and will eventually loosen the holding power as the brake shoes wear. Adjustment needs to be made once the handle reaches the end of its travel and the proper brake tension is not set or this tension is not reached in the desired amount of handle travel. There is no other parking mechanism on the vehicle that holds it in place when parked, so it is important to adjust as soon as it is needed. The adjustment for the park brake can be found under the vehicle at the equalizer junction point. The process is described in section 5.5.2 and 5.5.4.

Chapter 3: Batteries and Charger

3.1.1 Lead Acid Battery Safety

*This section contains important safety and operating information for your battery system and charger. Please read all of the safety information before performing any type of maintenance or repair on the battery system.

Battery Safety Warnings

Always observe the following personal safety precautions when working with lead acid batteries.

1. Batteries normally produce explosive gases which can cause personal injury. Therefore, do not allow flames or sparks to come near the battery. When working near the battery, always shield your face, protect your eyes and provide ventilation.
2. Someone should be within range of your voice or close enough to come to your aid when you work near a battery.
3. Keep batteries out of reach of children.
4. Batteries contain sulfuric acid. Avoid contact with skin, eyes or clothing. Shield your eyes when working near the battery to protect against possible splashing of acid solution. If battery acid contacts skin or clothing, wash immediately with soap and water. If acid comes in contact with eyes, flush immediately with water for a minimum of 15 minutes and seek medical attention. If acid is swallowed, call a physician immediately.
5. To avoid sparks when removing a battery, turn off all lights and accessories.
6. Connect only positive (+) cable to positive terminal, connect only negative (-) cable to negative terminal. Reversing polarity can be very dangerous.
7. Never smoke or allow a spark or flame in the vicinity of batteries.
8. Be extra cautious to reduce risk of dropping a metal tool onto a battery. It might spark or short-circuit the battery or other electrical part that may cause an explosion.
9. Remove personal metal items such as rings, bracelets, necklaces, and watches when working with a lead acid battery. A lead acid battery can produce a short-circuit current high enough to weld a ring or the like to metal, causing a severe burn

3.1.2 Testing Flooded Lead Acid Batteries

When testing batteries in the e-ride vehicle, it is important to test all batteries. Proper performance of the vehicle depends on all batteries being in good condition. Testing will determine if one (or more) of the batteries needs to be replaced.

Battery Discharge Test

A. The preferred testing procedure is to use the Lester Electrical 72 Volt Battery Discharge Unit (Model 25680). This instrument puts a known discharge load (75 Amps) on the battery pack until the battery pack reaches 63volts. A timer incorporated into the discharger measures the time needed to reach that voltage level. Battery capacity and remaining life can be determined from the test results. This item can be purchased from e-ride Industries as part# U5622A. Using the discharger is an easier more accurate method but requires some up front cost. If you have multiple vehicles we highly recommend you to purchase this 72 volt battery discharger. Perform the test as follows:

1. First refer to discharge unit operating instructions to fully understand the safety and operation of the unit.
2. Turn off the main battery disconnect.
3. Remove all access panels to the battery pack. (see section 2.2.1)
4. Hook up the negative cable clamp of the discharger to B- of the battery pack.
5. Hook up the positive cable clamp of the discharger to B+ of the battery pack.
6. Run discharger as described in the dischargers operating instructions.
7. When the discharger is running its test, randomly test each battery sequentially in the pack individually with a multi-meter and record the readings. Battery voltage should fall between 8.0 – 7.0 volts. 8.0 is fully charged. 7.0 is completely empty. This will help give you an understanding of how each individual battery is performing.
8. The discharger will draw constant amperage of 80 amps. It takes 90-120 charge cycles to achieve full battery capacity. A new seasoned battery pack operating at 80°F (26.7°C) should have 112 AH of capacity. At this load the discharger should run 1 hour 24 minuets (84 mins).
9. If discharge times are low, as described in the discharger instructions run the test a second time right away. The discharger will operate for 3 more minuets which gives you enough time to get a final individual battery voltage reading. Compare individual battery voltages recorded.

The results of the test can sometimes lead to several different conclusions about the battery pack and require varied action. The following goes over the results and the conclusions to be drawn from them:

1. If discharge time was 80 minutes or longer the issue is usually not with the batteries.
2. If discharge times are low, compare individual battery voltages recorded. If any battery shows a 0.4 volt or greater variance, that battery is bad or nearing the end of its useful life and should be replaced. The voltage of a bad battery will drop more rapidly near the end of the discharge than that of a good battery.
3. If all batteries are within 0.30 volts of each other, but the discharge time is low, the batteries are approaching the end of their life and the whole set will have to be replaced.
4. Other variables that need to be considered in this test is the battery temperature and Cycle life. If battery temperature is below or above 80°F (26.7°C) the overall capacity will lower or increase but the battery voltage

should still not vary 0.30 volts of each other. As for cycle life it takes 90-120 charge cycles to fully season the battery pack. Cycle cycles below this can lower the capacity as much as 20%. In other words a new battery pack performs to 80% its rated capacity.

B. If the Lester Battery Discharge Unit is not available, an alternate battery test can be done using a multimeter to perform a voltage test of each battery. The most inexpensive way to perform this test is to use the vehicle's drive system as its load. Perform the test as follows:

1. Charge the batteries until the charger shuts off.
2. Remove all access panels to the battery pack. (see section 2.2.1)
3. Make sure you have no loose components in the vehicle that could fall into the battery tunnel.
4. It will help to have two people to perform this test. One person to drive the vehicle and the other person use the multimeter to measure and record the voltage.
5. It is best to pick a course that is flat and long without many stops.
6. Record what time the test started.
7. Check the battery pack voltage every 10 minutes of driving. As soon as the battery pack voltage reaches 64 volts start measuring and recording each battery to the nearest 0.01 volt until battery pack reaches 63 volts which is zero state of charge. At this point, record the time and the test is complete.

The results of the test can sometimes lead to several different conclusions about the battery pack and require varied action. The following goes over the results and the conclusions to be drawn from them:

1. If discharge time was 80 minutes or longer the issue is usually not with the batteries.
2. If discharge times are low, compare individual battery voltages recorded in step 7 above. If any battery shows a 0.4 volt or greater variance, that battery is bad or nearing the end of its useful life and should be replaced. The voltage of a bad battery will drop more rapidly near the end of the discharge than that of a good battery.
3. If all batteries are within 0.30 volts of each other, but the discharge time is low, the batteries are approaching the end of their life and the whole set will have to be replaced.
4. It takes 90-120 charge cycles to achieve full battery capacity. A new seasoned battery pack should have 112 AH of capacity. On flat, even terrain a stock vehicle draws about 85 amps per hour at 25 MPH giving you 80 minutes of drive time. Totaling 33 miles per charge.
5. Other variables that need to be considered in this test is the battery temperature, cycle life and amp draw. If battery temperature is below or above 80°F (26.7°C) the overall capacity will lower or increase but the battery voltage should still not vary 0.30 volts of each other. As for cycle

life it takes 90-120 charge cycles to fully season the battery pack. Cycles below this can lower the capacity as much as 20%. In other words a new battery pack performs to 80% its rated capacity. And as for amp draw this requires higher expensive equipment to be done accurately but what to consider here is if you are on a hilly terrain the vehicle will draw more lowing your overall run time.

Hydrometer Test

A third option for battery testing is to perform a specific gravity test of the battery electrolyte using a hydrometer. A hydrometer measures the specific gravity. An increase in the specific gravity correlates directly to an increase in battery state of charge. A fully charged battery should read between 1.250 and 1.280 at 80°F. Never add acid to a battery to obtain a higher specific gravity.

Performing the hydrometer test

1. Be sure the batteries have sufficient water to cover the plates by approximately 1/2" and are fully charged prior to beginning the test. If distilled water must be added, recharge the batteries before performing the hydrometer test.
2. Flip open the cover of the battery filling float assembly. Locate the white plug under the cover and remove it. These holes should provide enough access to be able to perform all tests.
3. Using a battery thermometer, record the electrolyte temperature of one of the middle cells.
4. Squeeze the rubber bulb of the hydrometer and insert it into the cell of the battery. Slowly release the bulb, drawing the electrolyte into the hydrometer. Fill and drain the hydro meter two to four times before drawing a sample.
5. When the hydrometer float rises off the bottom, adjust the electrolyte level so the float floats freely from the bottom but does not strike the top of the glass tube. Remove the hydrometer from the cell and release the pressure from the bulb.
6. Hold the hydrometer vertically, ensuring that the float is not contacting the sides of the barrel. Hold the hydrometer at eye level and read the scale at the level of the electrolyte.
7. Record the reading.
8. Return the electrolyte to the cell from which it was taken. Close float cap and replace the white plug.
9. Repeat steps 2-8 on all cells.
10. Temperature correct each cell reading. The readings obtained as described above must be corrected for temperature. Temperature correct each cell reading. For each 10°F (5.5°C) above 80°F (26.7°C) add 0.004 to the specific gravity reading. For each 10°F (5.5°C) below 80°F (26.7°C) subtract 0.004 from the specific gravity reading.

Example:	Cell Temperature	100°F

Cell Specific Gravity Reading	1.245
ADD (20° above 80° F)	0.008
Correction to 80° F	1.253

11. The specific gravity of all battery cells should be 1.277 + or - 0.007. If low cell readings exist (see chart below), charge battery and take specific gravity readings again.
12. If specific gravity of any cells remains low after complete charging, battery should be replaced.

Battery Charge Level	Specific Gravity	Open Circuit Voltage
100%	1.277	8.49
90%	1.258	8.41
80%	1.238	8.33
70%	1.217	8.25
60%	1.195	8.16
50%	1.172	8.07
40%	1.148	7.97
30%	1.124	7.88
20%	1.098	7.77
10%	1.073	7.67

3.1.3 Lead Acid Battery Replacement

*Do not attempt to under take the battery replacement procedure without first reading Section 3.1 about all the safety precautions to be taken prior to working directly with the battery pack.

Battery Disassembly

1. Before any thing is disassembled, first turn off the main battery disconnect. An important note is that **disconnecting the battery disconnect switch does not kill power from a battery post or the cables between the batteries**. This should still be the first step before any electrical work is done on the vehicle.
2. Begin inside the vehicle cab from the top of the battery tunnel. Remove the center arm rest pad and console. The park brake lever (if ratcheting handle type) will have to be in the engaged position so that the handle is raised in order to remove the center pad (and tunnel cover once the console is removed later). Disconnect the wiring harness plug from the console then the console can then be slid back slightly, lifted up and removed. The heater tube hoses might have to be removed from the console if the vehicle is equipped with a heater. The center aluminum tunnel cover, which is attached by Velcro, can then be lifted off.
3. On an EXV2, the cab access area only reaches a limited amount of the batteries, so there is another access point from the top of the flatbed. Remove the panel in this area by releasing the four quarter-turn fasteners that secure it.

The batteries can all be removed through these access areas, but some of the following steps may have to be shuffled depending on what is easier for each person who attempts it.

4. See section 5.5.1 steps 1-3 for the disassembly of the parking brake handle.
5. The battery float caps for the filling system can now be removed starting with the front battery. Each float (BFS) cap is attached to the fill hose so the floats will have to be laid aside so that they will not get in the way of the rest of the disassembly, but so that they will not get acid on anything that might be sensitive to it. Remove the BFS caps from the front battery and replace them with the single battery caps that come on the new batteries.
6. Next remove the caps from the next battery in line. Once the float caps for a battery have been removed you can now access the battery jumper cable that runs underneath the fill system. Remove the battery jumper cable that is accessible. While taking the cables off, make sure that the loose end is not in contact with anything that could cause arcing until the other end of the jumper cable can be removed as well. Place another cap from the new batteries onto the next battery.
7. Continue repeating step 6 for one battery at a time until the entire watering system has been removed and replaced with individual battery caps and all the battery cable jumpers have been removed.
8. At this point, the cable from the main power disconnect to the first battery (-) post and the battery cable from the rear battery (+) post that goes to the main drive fuse as well as all other wires that are attached to the rear battery post stud can be removed. Also remove the plug for the float sensor found in the rear battery.
9. Remove the battery hold-down system bars across the top of each pair of batteries and remove the batteries from the chassis. Lift the batteries using the hooks on the outside of the case or support from the bottom of the battery. Do not lift the batteries by the terminal posts.
10. Once the old batteries are removed from the chassis, put all the individual caps back on the new batteries for installation into the chassis.

<u>Battery Assembly</u>

1. Locate the battery with the stud posts that will be the rear battery. Using a hole saw, drill a 1 1/16" hole in the battery top centered 2 1/8" from the edge opposite the posts and 7/8" from the passenger side of the battery (the battery sits in the vehicle with the posts to the rear). Take care to keep the debris from the drilling process out of the battery. Use light pressure on the drill so there is very little drill penetration past the plastic face that is being removed.
2. Pry the battery float plug from the old rear battery and clean the silicone from around the mating surface. Using clear silicone, reapply a bead around the circumference of the float plug and install into the new battery hole. Allow the silicone to set up before moving the battery.
3. Install the batteries (with the individual caps in place). Install the batteries one at a time and reattach the battery hold-down hooks and brackets. The hold-down hooks will have to be installed prior to the batteries or alternatively ahead of each battery. Install hooks from the inside of the battery hold-down

rails. Note that the battery with the stud posts and the float sensor will go in the rear.

4. Assemble the battery water system and jumper cables in the reverse order they were disassembled. Use the same method of installing one cable and one battery's floats at a time. The cables should be attached from positive post of one battery to the negative post of the next. Leave a positive post on the rear battery for the cable from the main drive fuse and the negative post on the front battery for the cable from the main disconnect switch. Both of these cables will be assembled last. Notice that the jumper cables have red and black heat shrink and should be connected to the corresponding posts of the batteries (Red-Positive and Black-Negative). Also note that the positive and negative posts are a different size and the cables are made accordingly. There is a taper on the posts and the cables should be assembled to match. Make sure that all connections are clean and tight and that all battery floats are fastened securely before proceeding.
5. Reattach the cable from the main drive fuse to the positive (+) post on the rear battery and the cable from the main disconnect switch to the negative (-) post on the front battery. Also, replace any wires to the positive post stud on the rear battery. Connect the appropriate wiring harness plug to the battery float sensor plug.
6. Charge the batteries completely before operating the vehicle.
7. Fill the battery water only after charging and before operating the vehicle.

Battery Disposal

Always dispose of batteries in a responsible manner. Follow your local authorized standards for disposal. Call your local authorized recycling center to find out more about recycling batteries.

3.1.4 Optimizing Lead Acid Battery Performance

Battery Seasoning (Break-in)

When the batteries are new, make sure to charge the battery pack before its first use. Limit the use of new batteries for first five cycles. New batteries are not capable of their rated output until they have been discharged a number of times. It takes 90-120 cycles to fully maximize range.

Battery Cycling and Life

Do not excessively discharge batteries. Excessive discharge (below 63 volts) can cause polarity reversal of individual cells resulting in complete failure shortly thereafter. Routinely heavy discharging will also reduce the battery overall life as shown in Table 2 below. The battery depth of discharge as it relates to overall battery life is also shown in this table. Limited use of new batteries will also minimize the chance of cell reversal. Charge the batteries to their full state every two months whether you have used them or not to ensure they will not fully discharged.

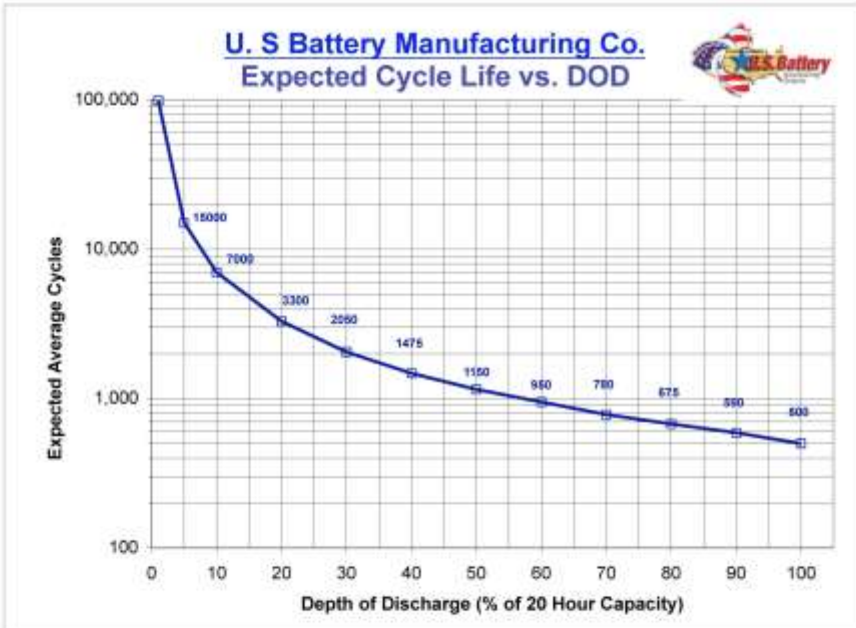
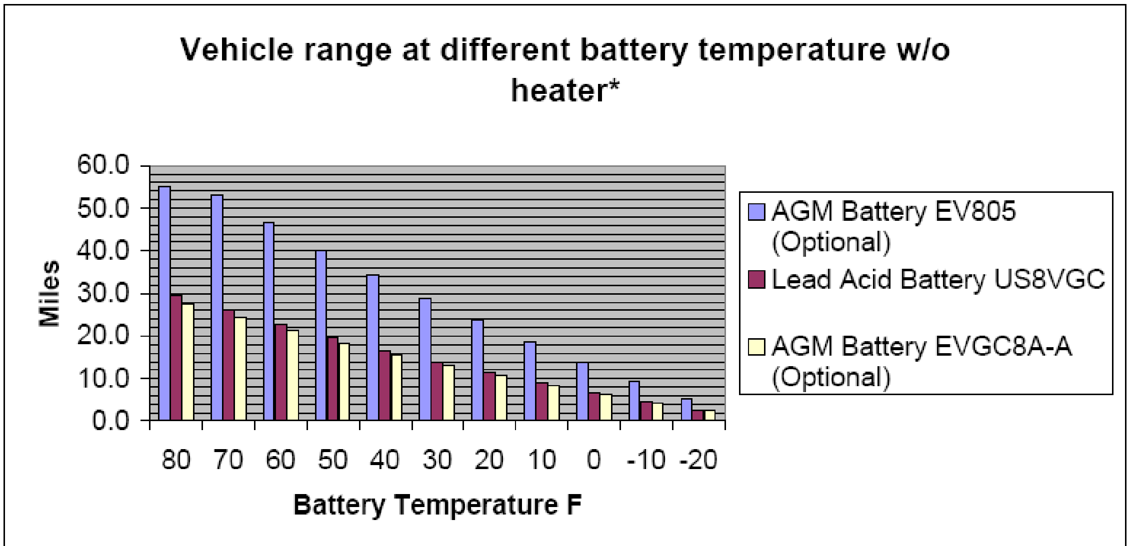


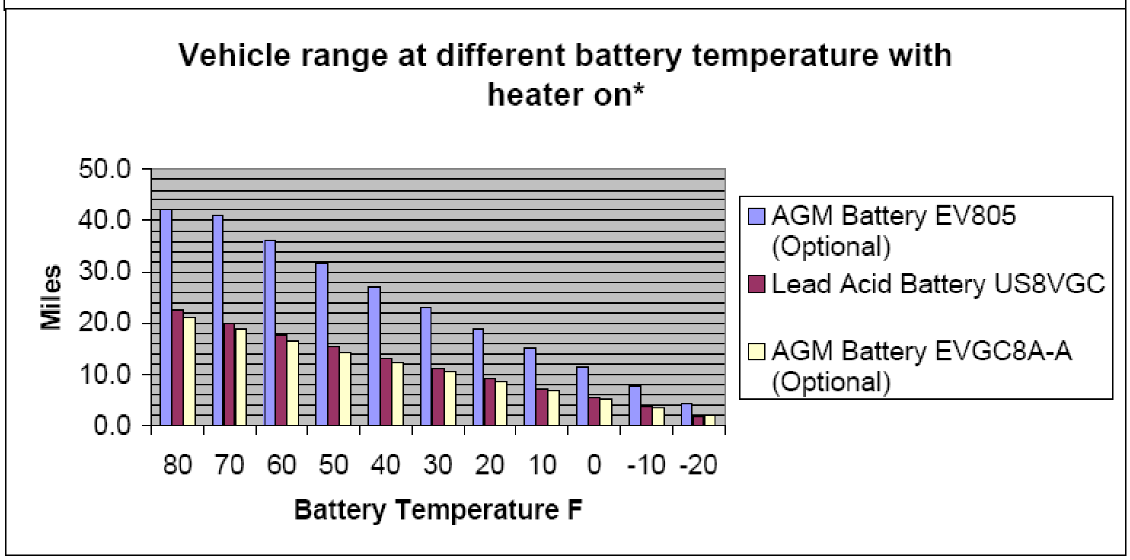
Figure 2: Discharge Depth vs. Battery Life

<u>How temperature affects a batteries available capacity and charge time</u>

A batteries available capacity varies at various temperatures. As the ambient temperature rises a batteries ability to deliver current increases. As the temperature falls, so does the batteries ability to deliver current.

E-ride Vehicle Range at Different Battery Temperatures





*These tests were preformed with an EXV2 model equipped with an enclosed cab. Vehicle weight with one drive was 2050 lbs. with the US8VGC & EVGC8A-A batteries, 2400 lbs with EV805 batteries. This vehicle was driven on a course that was a 3 mile loop. It has two complete stops and mostly flat but has some moderate hills.

Figure 3: Range vs. battery temp.

Cleaning and Maintenance

Make sure to fill batteries with water monthly or promptly when there is any indicated need. The batteries must be refilled with distilled or de-mineralized water to avoid internal damage. Electrolyte levels lower during discharge and rise during charge. **Therefore, it is mandatory that water be added to cells ONLY when they are fully charged.** Older batteries may require more frequent watering than new batteries. (See section 2.2 for battery watering procedure) Keep the top of the batteries clean and dry to insure longer lasting, trouble-free operations. Also, make certain the battery cables are always tightly fastened to the battery terminals. Make sure the cables are tight to the terminals but be careful not to over tighten. Any corrosion present on the batteries or terminals should be cleaned promptly by brushing them off with a wire brush. The acid can be neutralized with a solution of baking soda and water.

3.1.5 Lead Acid Battery Storage

If the vehicle will be stored for any period of time, check battery electrolyte level, adjust level if needed and then connect battery charger to vehicle. Allow charger to re-main connected to vehicle during storage to prevent battery discharge and potential battery damage. If the vehicle will be stored for more than 30 days and the battery charger cannot be used for some reason, charge the batteries fully. Either store batteries on a shelf or in the vehicle. Store the batteries in a cool atmosphere to avoid quick deterioration of the charge in the batteries. To prevent batteries from freezing, make sure they are fully charged before storage. During the storage period, charge the batteries at least once every three (3) months to prevent battery damage. Before returning the vehicle to service, make sure to fully charge the batteries. Batteries ending there life can discharge faster.

Do not park the vehicle and leave it for any length of time with discharged batteries. The batteries could discharge to the point where damage could occur and the battery charger will not charge. If you allow the vehicle to sit in conditions of 32°F (0°C) or less with a state of charge of 20% or less, the batteries could freeze. If the batteries happen to freeze, it may cause damage to the batteries and permanently reduce their capacity. The battery case could also crack if it is frozen. Inspect for this before attempting to thaw. Place the vehicle in an area greater than 32°F and allow it to warm up before charging. Never charge the vehicle if the batteries may be frozen.

When storing batteries during off-season or any time while the vehicle is not in use for any length of time, follow these guide lines to help keep the batteries in good condition.

1. Keep the batteries clean and free of corrosion as outlined in section 3.5.3.
2. Fully charge the batteries prior to storage.
3. Store in a cool area. The colder temperature in which the batteries are stored, the less they will self discharge. Batteries stored at 0°F will discharge very little over a four month period. Batteries stored at 80°F will have to be recharged every few weeks.
4. The frequency of recharging required will depend on the temperature of the storage area, but it is recommended that the batteries be monitored for state of charge every month. Also, if the storage area is unheated in a cold climate recharge is required. It is recommended that the area be heated to at least 60°F prior to charge. Batteries do not charge effectively in cold temperatures for the same reason that they do not discharge as rapidly in cold temperatures.

5. Check the state of charge periodically. Batteries that are discharged and left in the cold environment can freeze and crack. If the specific gravity drops below 1.220, the batteries should be recharged. See Table 2 below.

The following table shows the freezing point of a battery based on the specific gravity of the acid. This gives a guideline for working temperatures at a certain specific gravity.

Specific gravity	Freezing point Deg F.
1.26	-70
1.23	-39
1.20	-16
1.17	-2
1.11	17

Table 2: Battery Freezing Point

3.2.1 AGM Battery Safety

Battery Safety Warnings

*This section contains important safety and operating information for your battery system and charger. Please read all of the safety information before performing any type of maintenance or repair on the battery system.

IMPORTANT Handling Symbols:

Do not add water. Do not add electrolyte.
AGM Traction Dry Cell Batteries have a recognized gas recombination efficiency greater than 99.9% - are sealed, non-spillable and maintenance-free.

Do not throw in the garbage. This product is 98% recyclable product and must be processed via a recognized recycling agency.

High Voltage. Risk of shock. Do not touch uninsulated terminals or connectors.

Do not tamper with product labeling, container or vents. **Do not open vent caps.** WARRANTY IS VOID if product is tampered with.

This product must be recycled and is made of recycled products.

Pb

Contains lead. California Proposition 65 Warning: Battery posts, terminals, and related accessories contain lead and lead components, chemicals known to the State of California to cause cancer and reproductive harm. Wash hands after handling.

Always observe the following personal safety precautions when working with AGM batteries.

1. Batteries normally produce explosive gases which can cause personal injury. Therefore, do not allow flames or sparks to come near the battery. When working near the battery, always shield your face, protect your eyes and provide ventilation.
2. Someone should be within range of your voice or close enough to come to your aid when you work near a battery.
3. Keep batteries out of reach of children.
4. Batteries contain sulfuric acid. Avoid contact with skin, eyes or clothing. Shield your eyes when working near the battery to protect against possible splashing of acid solution. If battery acid contacts skin or clothing, wash immediately with soap and water. If acid comes in contact with eyes, flush immediately with water for a minimum of 15 minutes and seek medical attention. If acid is swallowed, call a physician immediately.
5. To avoid sparks when removing a battery, turn off all lights and accessories.
6. Connect only positive (+) cable to positive terminal, connect only negative (-) cable to negative terminal. Reversing polarity can be very dangerous.
7. Never smoke or allow a spark or flame in the vicinity of batteries.
8. Be extra cautious to reduce risk of dropping a metal tool onto a battery. It might spark or short-circuit the battery or other electrical part that may cause an explosion.
9. Remove personal metal items such as rings, bracelets, necklaces, and watches when working with a lead acid battery. A lead acid battery can produce a short-circuit current high enough to weld a ring or the like to metal, causing a severe burn.
10. DO NOT rinse or spray battery pack with water hose
11. Regularly inspect cables and re-torque terminals.
12. DO NOT leave battery in discharged state as this will shorten the life.

3.2.2 Testing AGM Batteries

<u>Battery Discharge Test</u>

A. The preferred testing procedure is to use the Lester Electrical 72 Volt Battery Discharge Unit (Model 25680). This instrument puts a known discharge load (75 Amps) on the battery pack until the battery pack reaches 63volts. A timer incorporated into the discharger measures the time needed to reach that voltage level. Battery capacity and remaining life can be determined from the test results. This item can be purchased from e-ride Industries as part# U5622A. Using the discharger is an easier more accurate method but requires some up front cost. If you have multiple vehicles we highly recommend you to purchase this 72 volt battery discharger. Perform the test as follows:

1. First refer to discharge unit operating instructions to fully understand the safety and operation of the unit.
2. Turn off the main battery disconnect.
3. Remove all access panels to the battery pack. (see section 2.2.1)
4. Hook up the negative cable clamp of the discharger to B- of the battery pack.
5. Hook up the positive cable clamp of the discharger to B+ of the battery pack.
6. Run discharger as described in the dischargers operating instructions.
7. When the discharger is running its test, randomly test each battery sequentially in the pack individually with a multi-meter and record the readings. Battery voltage should fall between 8.0 – 7.0 volts. 8.0 is fully charged. 7.0 is completely empty. This will help give you an understanding of how each individual battery is performing.
8. The discharger will draw constant amperage of 75 amps. It takes 25 charge cycles to achieve full battery capacity. A new seasoned battery pack operating at 80°F (26.7°C) should have 93 AH of capacity. At this load the discharger should run 1 hour 14 minuets (74 mins). If you have the optional 230AH battery pack then a new seasoned battery pack operating at 80°F (26.7°C) should have 188 AH of capacity. At this load the discharger should run 2 hour 31 minuets (151 mins).
9. If discharge times are low, as described in the discharger instructions run the test a second time right away. The discharger will operate for 3 more minuets which gives you enough time to get a final individual battery voltage reading. Compare individual battery voltages recorded.

The results of the test can sometimes lead to several different conclusions about the battery pack and require varied action. The following goes over the results and the conclusions to be drawn from them:

1. If discharge time was 70 minutes or longer (150 minutes with the 230AH battery pack) the issue is usually not with the batteries.
2. If discharge times are low, compare individual battery voltages recorded. If any battery shows a 0.4 volt or greater variance, that battery is bad or nearing the end of its useful life and should be replaced. The voltage of a bad battery will drop more rapidly near the end of the discharge than that of a good battery.
3. If all batteries are within 0.30 volts of each other, but the discharge time is low, the batteries are approaching the end of their life and the whole set will have to be replaced.

4. Other variables that need to be considered in this test is the battery temperature and cycle life. If battery temperature is below or above 68°F (20°C) the overall capacity will lower or increase but the battery voltage should still not vary 0.30 volts of each other. As for cycle life it takes 25 charge cycles to fully season the battery pack. Cycles below this can lower the capacity as much as 20%. In other words a new battery pack performs to 80% its rated capacity.

B. If the Lester Battery Discharge Unit is not available, an alternate battery test can be done using a multimeter to perform a voltage test of each battery. The most inexpensive way to perform this test is to use the vehicle's drive system as its load. Perform the test as follows:

1. Charge the batteries until the charger shuts off.
2. Remove all access panels to the battery pack. (see section 2.2.1)
3. Make sure you have no loose components in the vehicle that could fall into the battery tunnel.
4. It will help to have two people to perform this test. One person to drive the vehicle and the other person use the multimeter to measure and record the voltage.
5. It is best to pick a course that is flat and long without many stops.
6. Record what time the test started.
7. Check the battery pack voltage every 10 minutes of driving. As soon as the battery pack voltage reaches 64 volts start measuring and recording each battery to the nearest 0.01 volt until battery pack reaches 63 volts which is zero state of charge. At this point, record the time and the test is complete.

The results of the test can sometimes lead to several different conclusions about the battery pack and require varied action. The following goes over the results and the conclusions to be drawn from them:

1. If discharge time was 70 minutes or longer (150 minutes with the 230AH battery pack) the issue is usually not with the batteries.
2. If discharge times are low, compare individual battery voltages recorded in step 7 above. If any battery shows a 0.4 volt or greater variance, that battery is bad or nearing the end of its useful life and should be replaced. The voltage of a bad battery will drop more rapidly near the end of the discharge than that of a good battery.
3. If all batteries are within 0.30 volts of each other, but the discharge time is low, the batteries are approaching the end of their life and the whole set will have to be replaced.
4. It takes 25 charge cycles to achieve full battery capacity. A new seasoned battery pack at 68°F (20°C) should have 93 AH of capacity. On flat, even terrain a stock vehicle draws about 85 amps per hour at 25 MPH giving you 65 minutes of drive time. Totaling 27 miles per charge. If you have the optional 230 AH battery pack a new seasoned

battery pack should have 181 AH of capacity. On flat, even terrain a stock vehicle draws about 85 amps per hour at 25 MPH giving you 127 minutes of drive time. Totaling 53 miles per charge.

5. Other variables that need to be considered in this test is the battery temperature, cycle life and if amp draw was any higher. If battery temperature is below or above 68°F (20°C) the overall capacity will lower or increase but the battery voltage should still not vary 0.30 volts of each other. As for cycle life it takes 25 charge cycles to fully season the battery pack. Cycles below this can lower the capacity as much as 20%. In other words a new battery pack performs to 80% its rated capacity. And as for amp draw this requires higher expensive equipment to be done accurately but what to consider here is if you are on a hilly terrain the vehicle will draw more lowing your overall run time.

3.2.3 AGM Battery Replacement

*Do not attempt to under take the battery replacement procedure without first reading the beginning of this section about all the safety precautions to be taken prior to working directly with the battery pack.

Battery Disassembly

1. Before any thing is disassembled, first turn off the main battery disconnect. An important note is that **disconnecting the battery disconnect switch does not kill power from a battery post or the cables between the batteries**. This should still be the first step before any electrical work is done on the vehicle.
2. Begin inside the vehicle cab from the top of the battery tunnel. Remove the center arm rest pad and console. The park brake lever (if ratcheting handle type) will have to be in the engaged position so that the handle is raised in order to remove the center pad (and tunnel cover once the console is removed later). Disconnect the wiring harness plug from the console then the console can then be slid back slightly, lifted up and removed. The heater tube hoses might have to be removed from the console if the vehicle is equipped with a heater. The center aluminum tunnel cover, which is attached by Velcro, can then be lifted off.
3. On an EXV2, the cab access area only reaches a limited amount of the batteries, so there is another access point from the top of the flatbed. Remove the panel in this area by releasing the four quarter-turn fasteners that secure it. The batteries can all be removed through these access areas, but some of the following steps may have to be shuffled depending on what is easier for each person who attempts it.
4. Remove the battery jumper cable that is accessible. While taking the cables off, make sure that the loose end is not in contact with anything that could cause arcing until the other end of the jumper cable can be removed as well.

5. Continue repeating step 4 for one battery at a time until all the battery cable jumpers have been removed.
6. At this point, the cable from the main power disconnect to the first battery (-) post and the battery cable from the rear battery (+) post that goes to the main drive fuse as well as all other wires that are attached to the rear battery post stud can be removed.
7. Remove the battery hold-down system bars across the top of each pair of batteries and remove the batteries from the chassis. Lift the batteries using the hooks on the sides of the case or support from the bottom of the battery. Do not lift the batteries by the terminal posts.

Battery Assembly

1. Install the batteries one at a time and reattach the battery hold-down hooks and brackets. The hold-down hooks will have to be installed prior to the batteries or alternatively ahead of each battery. Install hooks from the inside of the battery hold-down rails.
2. Assemble the jumper cables in the reverse order they were disassembled. Use the same method of installing one cable at a time. The cables should be attached from positive post of one battery to the negative post of the next. Leave a positive post on the rear battery for the cable from the main drive fuse and the negative post on the front battery for the cable from the main disconnect switch. Both of these cables will be assembled last. Notice that the cables that have red and black heat shrink need to be connected to the corresponding posts of the batteries (Red-Positive and Black-Negative). Make sure that all connections are clean and tight.
3. Reattach the cable from the main drive fuse to the positive (+) post on the rear battery and the cable from the main disconnect switch to the negative (-) post on the front battery. Also, replace any wires to the positive post stud on the rear battery.
4. Charge the batteries completely before operating the vehicle.

Battery Disposal

Always dispose of batteries in a responsible manner. Follow your local authorized standards for disposal. Call your local authorized recycling center to find out more about recycling batteri

3.2.4 Optimizing AGM Battery Performance

Battery Seasoning (Break-in)

When the batteries are new, make sure to charge the battery pack before its first use. New batteries are not capable of their rated output until they have been discharged a number of times. It takes 25 cycles to fully maximize range.

Battery Cycling and Life

For normal overnight charging refer to the battery charger section. Do not excessively discharge batteries. Excessive discharge (below 63 volts) can cause polarity reversal of individual cells resulting in complete failure shortly thereafter. Routinely heavy discharging will also reduce the battery overall life as shown in

Table 2 below. The battery depth of discharge as it relates to overall battery life is also shown in this table. Limited use of new batteries will also minimize the chance of cell reversal. Charge the batteries to their full state every two months whether you have used them or not to ensure they will not fully discharged. For normal overnight charging refer to the battery charger section.

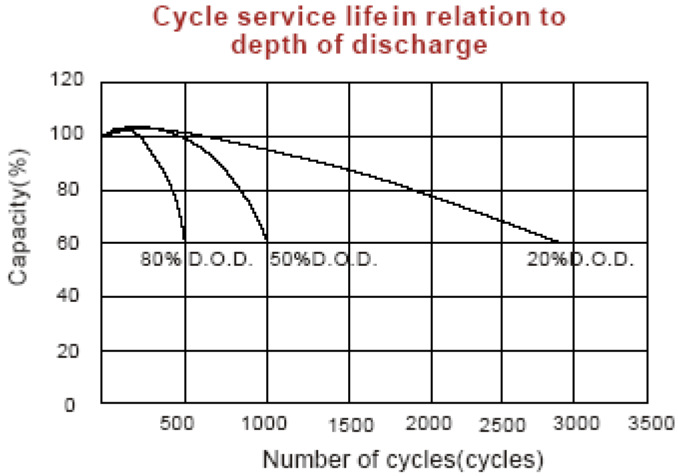


Figure 4: Discharge Depth vs. Battery Life

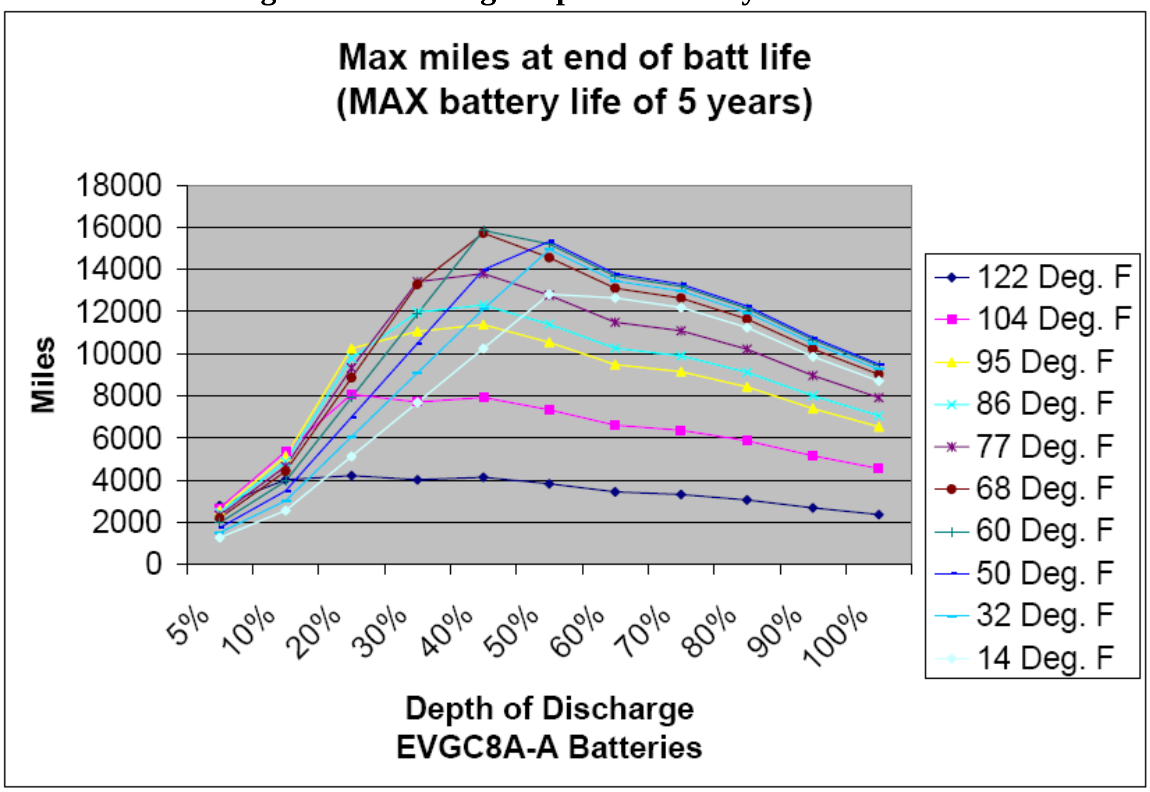


Figure 5: AGM 180 AH Batteries Max Miles vs. DOD vs. Temp.

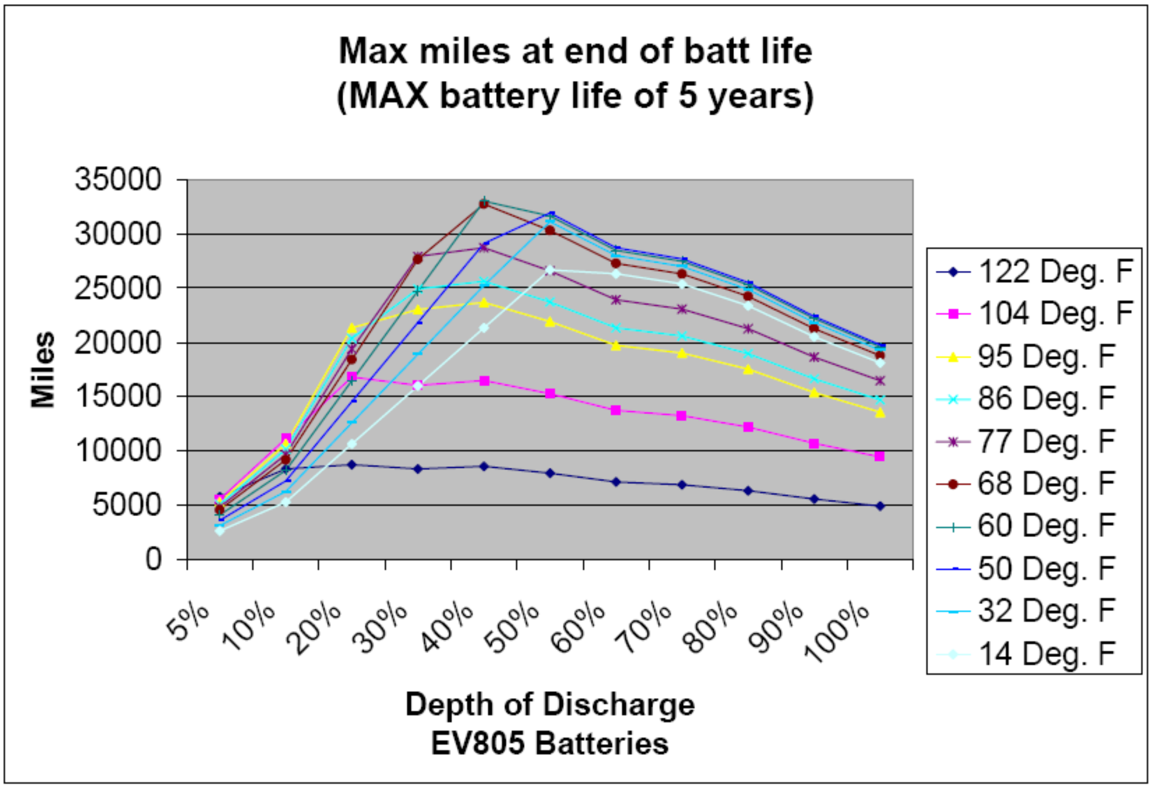


Figure 6: AGM 230 AH Batteries Max Miles vs. DOD vs. Temp.

Cleaning and Maintenance

Keep the top of the batteries clean and dry to insure longer lasting, trouble-free operations. Also, make certain the battery cables are always tightly fastened to the battery terminals. Make sure the cables are tight to the terminals but be careful not to over tighten. Any corrosion present on the batteries or terminals should be cleaned promptly by brushing them off with a wire brush. The acid can be neutralized with a solution of baking soda and water.

3.2.5 AGM Battery Storage

If the vehicle will be stored for any period of time allow charger to re-main connected to vehicle during storage to prevent battery discharge and potential battery damage. If the vehicle will be stored for more than 30 days and the battery charger cannot be used for some reason, charge the batteries fully. Either store batteries on a shelf or in the vehicle. Store the batteries in a cool atmosphere to avoid quick deterioration of the charge in the batteries. To prevent batteries from freezing, make sure they are fully charged before storage. During the storage period, charge the batteries at least once every three (3) months to prevent battery damage. Before returning the vehicle to service, make sure to fully charge the batteries. Batteries ending there life can discharge faster.

Do not park the vehicle and leave it for any length of time with discharged batteries. The batteries could discharge to the point where damage could occur and the battery charger will not charge. If you allow the vehicle to sit in conditions of 32°F (0°C) or less with a state of charge of 20% or less, the batteries could freeze. If the batteries happen to freeze, it may cause damage to the batteries and permanently reduce their capacity. The battery case could also crack if it is frozen. Inspect for this before attempting to thaw. Place the vehicle in an area greater than 32°F and allow it to warm up before charging. Never charge the vehicle if the batteries may be frozen.
When storing batteries during off-season or any time while the vehicle is not in use for any length of time, follow these guide lines to help keep the batteries in good condition.

1. Keep the batteries clean and free of corrosion
2. Fully charge the batteries prior to storage.
3. Store in a cool area. The colder temperature in which the batteries are stored, the less they will self discharge. Batteries stored at 0°F will discharge very little over a four month period. Batteries stored at 80°F will have to be recharged every few weeks.
4. The frequency of recharging required will depend on the temperature of the storage area, but it is recommended that the batteries be monitored for state of charge every month. Also, if the storage area is unheated in a cold climate recharge is required. It is recommended that the area be heated to at least 60°F prior to charge. Batteries do not charge effectively in cold temperatures for the same reason that they do not discharge as rapidly in cold temperatures.
5. Check the state of charge periodically.

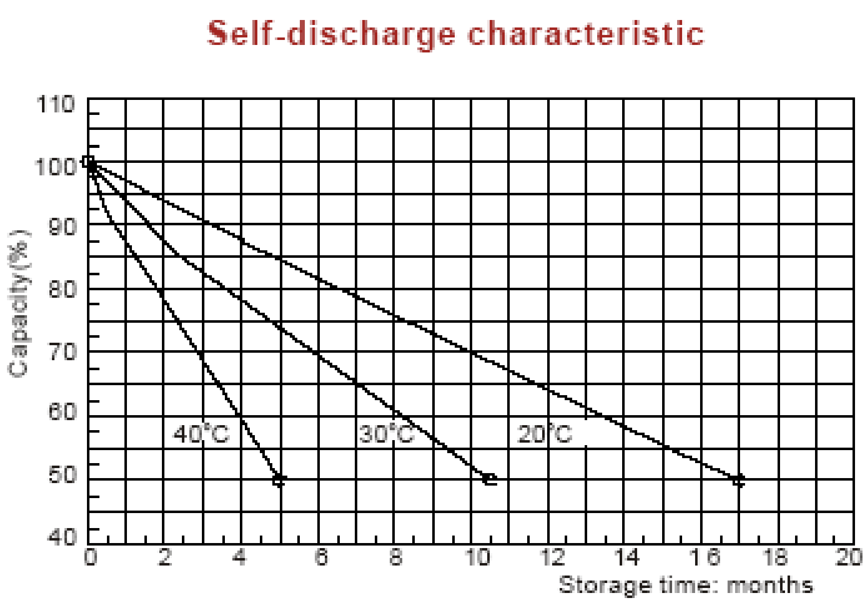


Figure 7: AGM Batteries Self-discharge Characteristics

Temperature Effects On Battery Performance & Life

Different temperatures affect the internal chemical reaction rates, and internal resistance and efficiency of all types of batteries.

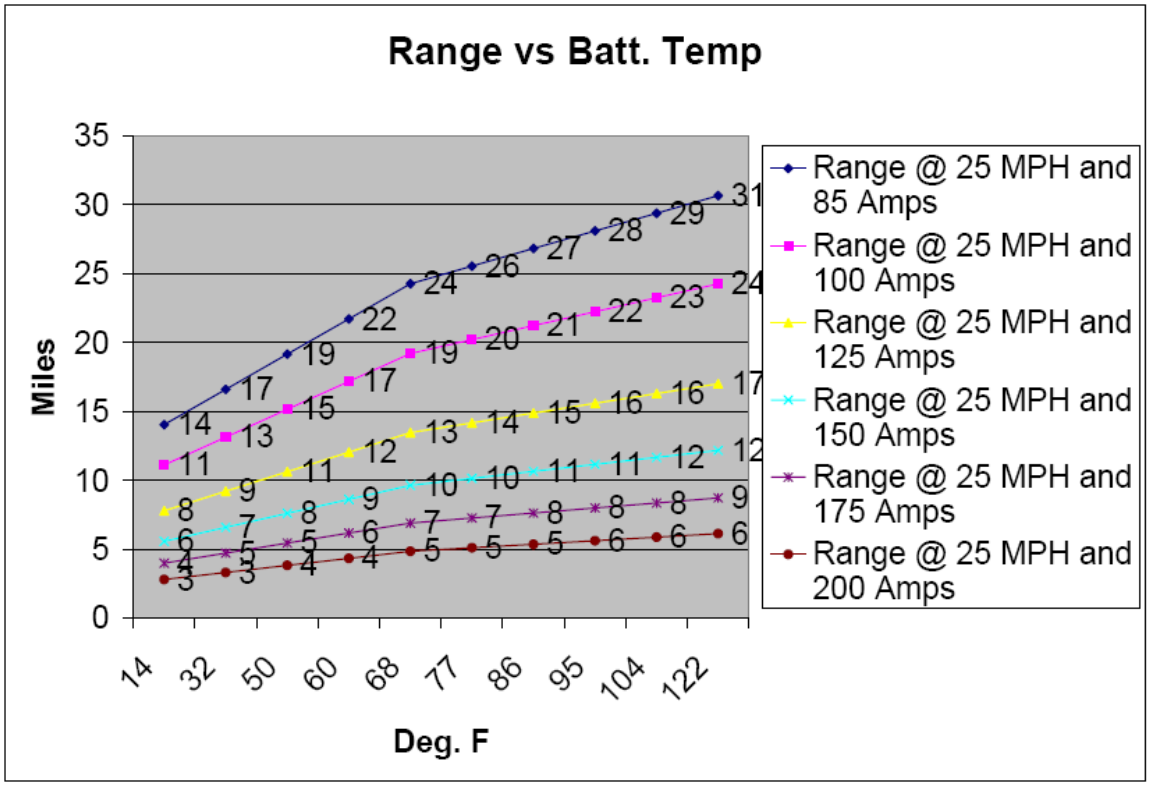


Figure 8: AGM 180 AH Battery Range vs. Temp. vs. Avg. Amp Draw

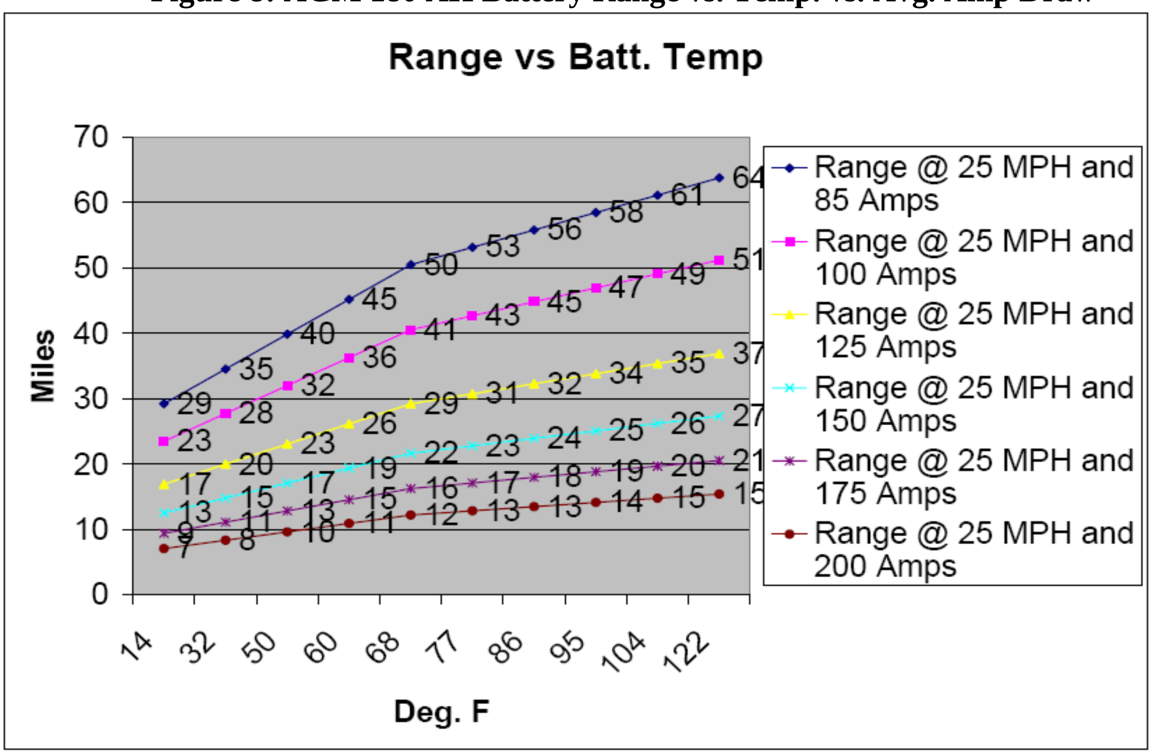
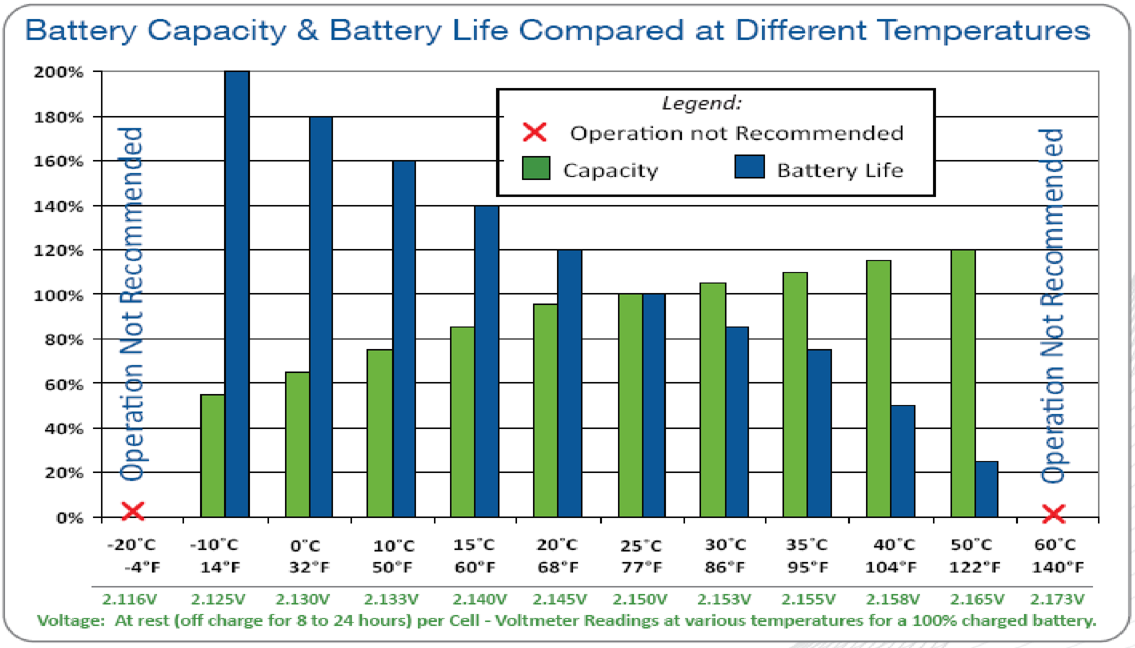


Figure 9: AGM 230 AH Battery Range vs. Temp. vs. Avg. Amp Draw



Data provided as representative only. Battery voltage, capacity and life will vary with actual environmental conditions and operator driving habits. Operation above 50˚C / 122°F and below -10˚C / 14°F is not recommended.

Temperature: C: Celsius, F: Fahrenheit.

Capacity: Operation or available "run time" as a % of base-line capacity established using industry standard testing at 25˚C / 77°F.

Battery Life: Expected battery life as a % of base line life established using industry standard testing at 25˚C / 77°F.

Voltage: Multiply the voltages shown by 3 for 6-volt batteries, by 4 for 8-volt batteries and by 6 for 12-volt batteries.

Figure 10: AGM Battery Capacity vs. Temperature

3.3 Charging (Only for vehicles build before 1/12/10)

Charger Safety Warnings

1. Charge only rechargeable batteries. Other types of batteries may burst causing personal injury and damage.
2. If either end of your charger plug becomes damaged in any way, make sure to replace it IMMEDIATELY.
3. Use of an attachment not recommended or sold by the vehicle manufacturer may result in the risk of fire, electrical shock, or injury to persons.
4. Do not operate the charger if it has received a sharp blow, been dropped, or otherwise damaged in any way; take it to a qualified service center.
5. To reduce the risk of electrical shock, unplug the charger from a live outlet or disconnect AC power to the outlet before attempting any maintenance or cleaning. Turning off controls will not reduce the risk of electric shock.
6. DO NOT use jumper cables to the batteries on this vehicle.
7. Only charge this vehicle with the appropriate battery charger that is supplied with the vehicle.
8. Lead acid batteries generate gases which can be explosive. Charge the batteries only in well ventilated areas.
9. Do not disconnect charger DC output terminals from battery when charger is on. The resulting arching and burning will damage the connectors and could cause the battery to explode.
10. Keep sparks, flame, and smoking materials away from battery.
11. Do not leave charger connected while unattended for more than two consecutive days. Severe overcharging and possible damage to batteries will result if charger should fail to turn off.
12. Never plug in both 120 volt and 220 volt cords at the same time. When one cord is plugged into one receptacle the other receptacle has live power also.
13. Never charge a frozen battery.
14. Do not lift a battery by the terminal posts, or internal damage may result.

Charger Operation

The battery charger is a self-regulating charger with a minimum of moving parts, designed for long, trouble free service. The charger utilizes convection cooling which maximizes the reliability and minimizes any maintenance costs. Charge only flooded, liquid electrolyte (wet) lead acid batteries with this charger.

Normal charging at the finish charge rate for the last three to five (3-5) hours is important to achieve equalization of all battery cells every time the batteries are charged. New batteries or batteries charged in cold temperatures (below 50 degrees F) will require more time to achieve full charge.
Charge time will vary depending on the depth of discharge. Allow 8 hours for normal charging. Fully discharged batteries may require up to 12 hours to be properly charged and equalized.

Charging Procedure

1. Connect the AC supply cord to the correct single phase outlet, located in the front bumper of the vehicle, with one of the proper voltages and frequencies as follows:
   -115 volts 16 amp 60 hertz
   -230 volts 13 amp 60 hertz
2. The charger will start after a short delay as indicated by the transformer hum and the ammeter movement.
3. Once the charge is completed the charger will turn off automatically. After the charger has turned off, disconnect the AC supply cord from the outlet.

Charging Battery Pack with Low Voltage

1. Turn the ignition switch off and set the parking brake.
2. If the battery pack voltage is reading below 34 volts the charger will not turn on. The charger relay will have to be by-passed in order for the charger to turn on.
3. Disconnect the DC cords from the vehicle.
4. Disconnect both AC cords from the charger’s electrical outlets.
5. Remove the 10 screws securing the charger cover and remove the cover from the charger.
6. Follow instructions listed below depending on which voltage you are using to charge the vehicle. Make note of the wires’ original positions, so they can be put back when the procedure is complete.
7. Plug the DC cords into the charger receptacle first and then plug the AC cord into the electrical outlet.
8. The charger should turn on and begin to charge the batteries. Allow the charger to operate for one to two hours, but not more than two hours.
9. After one to two hours, disconnect the charger AC cord from the electrical outlet first. Then, disconnect the DC cords from the charger.
10. Change the wires inside the charger back to their original location.
11. Re-install the charger cover and the 10 screws securing the cover.
12. Connect the DC cords to the charger first and then plug the AC cord into the electrical outlet.

13. The charger should turn on and begin to charge the batteries. Allow the charger to operate until the charger shuts off automatically.
14. When the charge cycle is complete, test the batteries again. If the battery pack voltage is above 34 volts and the vehicle will not operate, it will be necessary to troubleshoot the vehicle's electrical system to determine which electrical component has failed.

- **115 volt charging (See attached diagram)**
  I. Inside the charger locate the black wire that is going to terminal location #6 of the circuit board.
  II. Unplug this black wire and plug it into terminal location #3 of the circuit board.
  III. Locate the white wire going to terminal location #5 of the circuit board.
  IV. Unplug this white wire and plug it into terminal location #2 of the circuit board.

- **220 volt charging (See attached diagram)**
  I. Inside the charger locate the black wire that is going to terminal location #4 of the circuit board.
  II. Unplug this black wire and plug it into terminal location #3 of the circuit board.
  III. Locate the white wire going to terminal location #5 of the circuit board.
  IV. Unplug this white wire and plug it into terminal location #2 of the circuit board.

WIRING DIAGRAM

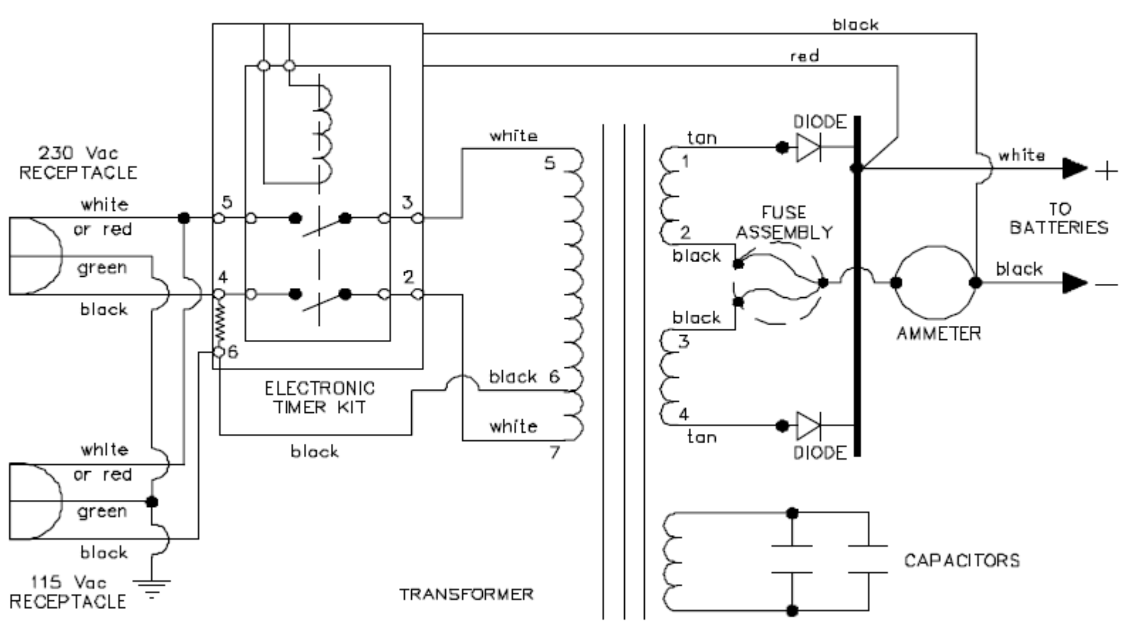


Figure 11: Charger Wiring Schematic

<u>Charger Troubleshooting Guide</u>

SECTION	MALFUNCTION SYMPTOM
1	**CHARGER DOES NOT TURN ON**
	A. Relay does not close, no transformer hum, and ammeter does not register.
	B. Relay closes but no transformer hum and ammeter does not register.
	C. Relay closes and transformer hums but ammeter does not register.
	D. Electronic timer kit replacement instructions
2	**CHARGER FUSE BLOWS**
	A. Single fuse link blows.
	B. Both fuse links blow.
3	**AMMETER READS 30 AMPS FOR MORE THAN 30 MINUTES**
4	**CHARGER OUTPUT IS LOW**
5	**CHARGER TURN OFF MALFUNCTIONS**
	A. Charger turns off too soon.
	B. Charger does not turn off.
	C. Charger runs too long but does turn off.
6	**AC LINE FUSE OR CIRCUIT BREAKER BLOWS**
7	**TRANSFORMER SHORT OR BURN-OUT**

SECTION 1 – CHARGER DOES NOT TURN ON

In normal operation, the charger DC output connector must be connected to the batteries in order to turn the charger on. A time delay of two to five (2-5) seconds is provided to allow adequate time to make a secure connection before the charger turns on. After this time delay, the power relay closes and an audible "click" should be heard. When the relay closes, AC power is supplied to the transformer primary coil. If operating properly, the transformer should hum and the ammeter should indicate the charge rate. If the charger does not turn on properly, refer to Part A, B or C for specific test procedures.

Part A Relay does not close, no transformer hum, and ammeter does not register

Check to be sure the power supply cord is securely connected to a live outlet. Check the DC output connector and the battery connector for damage, dirt or corrosion that would prevent a good electrical connection.

WARNING: IF THE PLUG OR RECEPTACLE IS BROKEN, TWISTED, BENT OR LOOSE AND DOES NOT MAKE GOOD ELECTRICAL CONTACT, HAVE IT REPLACED BY A QUALIFIED SERVICE AGENT IMMEDIATELY. DO NOT USE THE CHARGER IN THIS CONDITION AS FIRE OR PERSONAL INJURY CAN RESULT.

Then disconnect the power supply cord from its outlet. With the DC output connector still connected to the battery connector, measure the voltage at the battery connector using a suitable DC voltmeter. The voltage reading should be the same as the battery terminal voltage and must be 70% of the nominal rating of the battery pack. Example: 24VDC batteries need at least 16.8 VDC. If the DC voltage is within the above limits, remove the charger cover and verify that the charger is properly wired and you read the same voltage (24 to 50 VDC) inside the charger where the WHITE and BLACK wires of the DC cord attach. If the battery DC voltage measured inside the charger is now below the above limits or not present, the DC plug or cordset has an internal break and must be replaced. If the charger is wired correctly and a satisfactory battery DC voltage is measured inside the charger, a malfunction in the Electronic Timer Kit has probably occurred. Due to its complexity, do not attempt to make field repairs to any part of the Electronic Timer Kit. If a malfunction exists, simply remove the entire Electronic Timer Kit and replace it with a new one. Refer to Part D, "Electronic Timer Kit Replacement", for correct procedure. The Electronic Timer Kit may be bypassed in order to verify that a malfunction exists. First disconnect the charger power supply cord from its outlet and the DC output connector form the battery connector. Place a jumper wire between terminals #1 and #3 to bypass the Electronic Timer Kit as shown in Figures 1 and 2. The power supply cord is now connected directly to the primary transformer coil and the transformer should hum when the power supply cord is connected to a live outlet. The charger operation may be checked by first connecting the DC output connector to the battery connector, and then connecting the power supply cord to an outlet. If normal charging current is indicated on the ammeter, the Electronic Timer Kit is defective and must be replaced.

CAUTION: DO NOT CHARGE BATTERIES WITH THE ELECTRONIC TIMER KIT BYPASSED. THE CHARGER WILL REMAIN ON AS LONG AS THE POWER SUPPLY CORD IS CONNECTED TO AN OUTLET. SEVERE OVERCHARGING AND EVENTUAL DAMAGE TO BATTERIES WILL RESULT.

If the transformer does not hum and the ammeter still does not register with the Electronic Timer Kit bypassed, a continuity check of the charger AC circuit is necessary. Disconnect the power supply cord from its outlet and the DC output connector from the battery connector and, with a suitable continuity tester, check the circuit across the power supply cord prongs. With the Electronic Timer Kit bypassed, the CIRCUIT SHOULD BE COMPLETE. If the circuit is not complete, individually check the continuity of the power supply cord, primary transformer coil and all connections.

Part B Relay closes, but no transformer hum, and ammeter does not register

Check to be sure the power supply cord is securely connected to a live AC outlet. When three-prong to two-prong adapters are used, they tend to work loose, resulting in a poor connection. Check the AC line fuse or circuit breaker and, if possible, measure the AC line voltage at the outlet to be sure AC power is present. If necessary, connect a functioning charger, utility light, or other electrical appliance to the outlet to verify the presence of AC power. If AC power is present, disconnect the power supply cord from its outlet and the DC output connector from the battery connector. Bypass the Electronic Timer Kit as described in Section 1, Part A, and with a suitable continuity tester, check the circuit across the power supply cord prongs. With the Electronic Timer Kit bypassed, the CIRCUIT SHOULD BE COMPLETE. If the circuit is complete, refer to the Wiring Diagram and check the relay wiring and all connections. If the circuit is not complete, check the wiring of the power supply cord, transformer primary coil leads, and the Electronic Timer Kit. If the charger is wired correctly, individually check the continuity of the power supply cord, transformer primary and relay.

Part C Relay closes, and transformer hums, but ammeter does not register

If the relay closes and the transformer hums, the charger AC circuit and Electronic Timer Kit are functioning properly. If the ammeter does not register, a fault in the charger DC circuit exists and a continuity check must be performed. Disconnect the power supply cord from its outlet and the DC output connector from the battery connector, and check the charger fuse. If a fuse link is blown, refer to Section 2, "Charger Fuse Blows", for further tests. If the fuse checks good, use a low voltage continuity tester to perform the following tests:

1. Connect the tester leads to the charger DC output connector and note the readings. Reverse the tester leads and check the output connector again. The circuit should be complete in only one direction. If the circuit does not conduct in either direction and the fuse is good, individually check the continuity of the DC output cord, ammeter, diodes, and all connections. If the circuit conducts in both directions, a "short" exists in the charger DC circuit. First check the DC output cord for a "short" between the two wires. It is more likely that one or both diodes have "shorted". Refer to Section 2, "Charger Fuse Blows", for continuity test of diodes.
2. If the charger DC circuit test is good, a check of the capacitor is necessary. Disconnect the power supply cord from its outlet and the DC output connector from the battery connector.
   Then disconnect both transformer coil leads from the capacitor terminals. Use care when disconnecting the capacitor leads so the wires do not break. Using an ohmmeter, set the scale to R x 10K ohms and test the capacitor as follows:

   - **GOOD CAPACITOR** When the ohmmeter leads are connected to the capacitor terminals, the meter needle jumps to mid-scale and rapidly moves to higher resistance (:)

- **OPEN CAPACITOR** When the ohmmeter leads are connected to the capacitor terminals, the meter needle does not move and stays at high resistance (:). A bulge in the top of the capacitor may be visible if the capacitor has failed "Open".

- **SHORTED CAPACITOR** When the ohmmeter leads are connected to the capacitor terminals, the meter needle jumps immediately to zero ohms and remains there. If the capacitor is "Open" or "Shorted", it must be replaced.

CAUTION: USE ONLY THE PROPERLY RATED CAPACITOR FOR REPLACEMENT. THE USE OF A DIFFERENT VALUE CAPACITOR MAY RESULT IN IMPROPER CHARGING, CAPACITOR FAILURE, TRANSFORMER BURN-OUT, AND/OR BATTERY DAMAGE.

3. If the charger DC circuit and capacitor check good, a test of the transformer is necessary. Refer to Section 7, "Transformer Short or Burnout" for test procedures.

Part D Electronic Timer Kit replacement

The Electronic Timer Kit should always be replaced as a complete assembly. The tools required are a Phillips head screwdriver, 3/8" and 11/32" wrenches, and pliers. No soldering is required. To replace the kit, follow the step-by-step procedures listed below.

1. Disconnect the charger power supply cord from its outlet and the DC output connector from the battery connector, and remove the charger cover.
2. Disconnect the GREEN (if included), BLACK and RED wires of the Electronic Timer Kit. Then remove the BLACK and WHITE leads of the power supply cord and both primary transformer coil leads from the Electronic Timer Kit terminal tabs. The Kit can be removed by removing the three mounting screws on the charger front panel. Save all hardware for reassembly.
3. Install the replacement Electronic Timer Kit by reversing the disassembly procedures described in Step 2. When reconnecting the wires to the Electronic Timer Kit terminal tabs, support the terminal board to prevent damage to the electronic circuit board. Connect either transformer primary lead to terminal #2, and the remaining primary lead to terminal #3. Connect the BLACK lead of the power supply cord to terminal #1 on the Electronic Timer Kit and the WHITE lead of the power supply cord to terminal #2. Connect the RED wire of the Electronic Timer Kit along with the WHITE or RED lead of the DC cord to the Heatsink Assembly. Connect the BLACK wire of the Electronic Timer Kit along with the BLACK lead of the DC cord to the ammeter post. Do not allow the ammeter post to turn when tightening the nut. Reconnect the GREEN wire of the Electronic Timer Kit along with the transformer secondary lead to the diode lead terminal (if included).

   CAUTION: BE SURE ALL CONNECTIONS ARE CLEAN AND TIGHT. ALSO CHECK TO BE SURE ALL WIRES AND TERMINALS ARE POSITIONED SO THEY DO NOT SHORT TOGETHER OR TO THE CHARGER CASE.
4. Replace the charger cover and check the Electronic Timer Kit for proper operation as follows:
   a. With the DC output connector disconnected from the battery connector, insert the power supply cord into an outlet. The relay on the Electronic Timer Kit should not close. A DC voltmeter connected across the DC output connector should indicate zero volts.
   b. Disconnect the power supply cord from its outlet and connect the DC output connector to the battery connector. The relay on the Electronic Timer Kit should close with an audible "click" after a two to five (2-5) second delay.
   c. If the Electronic Timer Kit does not operate as (a) and (b) above, refer to the wiring diagram and check to be sure the charger is wired correctly. If the Electronic Timer Kit operates properly, the charger is ready for use. Always monitor the first charge cycle to verify that the charger is turning off properly.

SECTION 2 – CHARGER FUSE BLOWS

The charger fuse assembly consists of a dual element fuse link under a transparent cover mounted on the charger front panel. Each fuse element is electrically connected in series with a rectifier diode to provide protection for the transformer in the event of a diode failure. Visually inspect and electrically test the fuse to determine if one or both fuse links are blown and refer to Part A or Part B for test procedures. **Locate and correct cause of trouble before replacing blown fuse.** DO NOT attempt to repair the fuse link as inadequate protection will result.

Part A Single fuse link blows

This condition is normally caused by a short circuit failure of one diode. The fuse link will blow when the charger DC output connector is connected to the battery connector, regardless of whether the power supply cord is connected to an outlet. To check the diodes, disconnect the power supply cord from its outlet and the DC output connector from the battery connector, and then disconnect one transformer secondary coil lead from the diode terminal. Using a low voltage continuity tester, connect one tester lead to the diode mounting plate and the other tester lead to a diode terminal. Note the reading, then reverse the tester leads, and check each diode again. If a diode conducts current in both directions, it is "shorted" and the complete Heatsink Assembly with Diodes must be replaced.

Part B Both fuse links blow

This is normally caused by a reverse polarity connection between the charger DC output connector and the battery connector. Check the battery pack and battery connector to be sure they are wired in the correct polarity. If possible, check the voltage and polarity at the battery connector with a DC voltmeter. Also, check the charger DC output connector for the correct polarity. The WHITE or RED wire should be connected to the positive (+) contact, and the BLACK wire to the negative (-) contact. If a reverse polarity connection is made between the charger and batteries, both fuse links will blow regardless of whether the power supply cord is connected to an outlet.

SECTION 3 – AMMETER READS 30 AMPS FOR MORE THAN 30 MINUTES

This high output condition is caused by misuse, connecting the charger to an incorrect battery system which is lower than what is rated for the charger. A common error is to install one or more of the batteries in a battery pack reverse polarity. Using a suitable DC voltmeter, test to be sure all batteries in a battery pack are correctly wired, and also test the battery pack voltage at the charging connector. After charging for 30 minutes at this excessive rate, the measured on-charge voltage should rise to 34 to 38 volts DC for a 36-volt system. While charging, voltage measurements lower than this indicate an incorrect or failed battery pack that must be corrected before using the charger.

CAUTION: DO NOT CONNECT THE CHARGER TO BATTERY PACKS WHICH ARE NOT RATED FOR THE CHARGER. THIS MISUSE WILL CAUSE OVERHEATING AND TRANSFORMER BURN-OUT WILL RESULT.

SECTION 4 – CHARGER OUTPUT IS LOW

The most probable cause of low output is a single fuse link blowing as a result of a short circuit failure of one diode. Refer to Section 2, "Charger Fuse Blows", for troubleshooting procedures. On rare occasions, a short circuit failure of the transformer coils may cause the output to be low. Refer to Section 7, "Transformer Short or Burn-out", for test procedures. Another failure that could cause low output is an open diode on the heatsink assembly. To check for an open diode, follow the procedures in “Section 2 – CHARGER FUSE BLOWS, Part A Single fuse link blows” and test the continuity of both diodes. An open diode will not have continuity in either direction.

CAUTION: DO NOT USE THE CHARGER IF THE OUTPUT IS LOW. BATTERIES WILL NOT REACH FULL CHARGE, THEREBY INCREASING THE POSSIBILITY OF A HARMFUL DEEP DISCHARGE DURING THEIR NEXT USE.

SECTION 5 – CHARGER TURN-OFF MALFUNCTIONS

The Electronic Timer Kit turns the charger off as well as on. Proper charge time is determined by many factors, but the main elements are: (1) battery size, (2) depth of battery discharge, and (3) finish charge rate. Large, severely discharged batteries require more time to reach full charge than do smaller, lightly discharged batteries. The charge rate, as indiated by current flow in amperes on the panel meter, is controlled by the batteries' rising voltage during charge. The higher the on-charge voltage will rise, the lower the finish charge will be before the Electronic Timer terminates charging.

THE FOLLOWING TIMER MALFUNCTIONS ARE OCCASIONALLY DUE TO FACTORS OTHER THAN THE CHARGER'S PERFORMANCE. TO HELP ISOLATE THE PROBLEM, IT IS OFTEN NECESSARY TO USE THE CHARGER ON A DIFFERENT SET OF BATTERIES AND THE ORIGINAL SET OF BATTERIES ON ANOTHER CHARGER.

Part A Charger turns off too soon

Check to be sure the power supply cord is securely connected to a live outlet. If the power supply outlet is live, proceed with the next step. To determine if the charger did shut off too soon, disconnect and reconnect the charger DC output connector. This will restart the charger. Observe charger output on the ammeter.

1. The ammeter needle jumps smartly to between 20 and 25 amps and then tapers below 14 amps within 15 minutes. This indicates that the batteries were truly charged. The apparent short charging time is in response to the batteries' ability to accept charge and the electronic timer is performing properly.
2. The ammeter needle jumps smartly to between 20 and 25 amps, but does not taper below 14 amps within 15 minutes. If the batteries have been properly maintained and charged regularly, this generally indicates that the batteries were not fully charged. If possible, use a hydrometer to check the specific gravity of several battery cells. If the specific gravity readings are more than 30 points (.030) lower than normal full charge readings, the electronic timer has malfunctioned and the complete Electronic Timer Kit must be replaced. Refer to Section 1, Part D, "Electronic Timer Replacement", for correct procedure. If the batteries have not been used or charged regularly, they may be sulfated and will not produce their full capacity. Repeated cycles (at least 5) of a light discharge, followed by a full charge, will generally result in the recovery of most of the battery's capacity. Do not interpret this reduced battery capacity as being caused by the charger's turning off too soon. The charger is working properly if, after several charge cycles, the battery capacity increases to near normal. Sulfation occurs most often when the batteries have been stored without weekly charging. New batteries may also be sulfated due to extended shipment or storage time prior to sale. As batteries age, individual cells may weaken, causing a reduction in battery capacity. This condition normally results in a finish charge rate higher than 10 amps and less time is required to fully charge the batteries. Do not interpret this shorter charging time and reduced battery capacity as being caused by the charger's turning off too soon. The battery is aging naturally and the charger is working properly. When the batteries will not longer perform as required, they should be replaced.

Part B Charger does not turn off

New batteries with all good cells should rise to at least 2.5 volts per cell. This will allow the finish charge rate to taper below 8 amperes. As batteries age, individual cells may weaken and these cells may not reach 2.5 volts. This will result in finish charge rates greater than 8 amperes, and less time will be required for the batteries to reach full charge. At a finish charge rate of 8 amperes or less, the charge time should not exceed 18 hours. At a finish charge rate greater than 8 amperes, the charge time should not exceed 14 hours. If the charger remains on longer than the specified maximum time, check to see if the charger turns on immediately when the DC output cord is connected without the normal two to five (2-5) second delay. If the charger turns on instantly without the 2-5 second delay, the Electronic Timer Kit has probably failed. This type of malfunction generally results in the charger not turning off and the complete Electronic Timer Kit must be replaced. Refer to Section 1, Part D, "Electronic Timer Kit Replacement", for correct procedures. If the charger remains on longer than the maximum time specified and the two to five (2-5) second delay is present, verify that the

GREEN wire from the Electronic Timer Kit and the secondary transformer coil lead are securely connected to the diode lead (Not all Electronic Timer Kits will have a GREEN wire.) The charger will NOT turn off if the GREEN wire is loose or disconnected. If the GREEN wire is securely connected, the Electronic Timer Kit has malfunctioned and the complete Electronic Timer Kit must be replaced. If a precision digital type DC voltmeter is available, a test to verify that the Electronic Timer has malfunctioned can be made. Connect the charger to the batteries and allow to charge normally. After the charge rate has tapered to its lowest point, measure the battery terminal voltage using a DC voltmeter capable of reading in increments of .001 volts. Continue charging and check the battery voltage reading every hour. If the battery voltage increases less than .012 volts, or if the battery voltage decreases between successive hourly readings, the charger should turn off. If the charger does not turn off, the Electronic Timer has malfunctioned and the complete Electronic Timer Kit must be replaced.

Part C Charger runs too long but does turn off

In the event of AC power interruption when the charger is on, the charger will automatically restart when AC power is restored. This power outage can make the apparent charge time seem longer than the actual charge time. To check for AC power Troubleshooting Guide 7 31039B interruptions, plug an electric clock into the same outlet to which the AC cord is connected. Charge normally and note any time difference between the test clock time and the actual time.

SECTION 6 – AC LINE FUSE OR CIRCUIT BREAKER BLOWS

If this occurs when the charger power supply cord is connected to an outlet, without the DC output connector connected to the battery connector, the charger power supply cord may be shorted. Disconnect the power supply cord from its outlet and the DC output connector from the battery connector, then check to be sure the Electronic Timer Kit is NOT bypassed. With a suitable continuity tester, check the circuit across the power supply cord prongs. THE CIRCUIT SHOULD NOT BE COMPLETE. If the circuit is complete, check the relay contacts to be sure they are open and have not welded closed. If the relay contacts are open, the power supply cord is shorted and must be replaced. If the power supply cord checks good, the transformer coils may be shorted. Refer to Section 7, "Transformer Short or Burn-out", for test procedures.

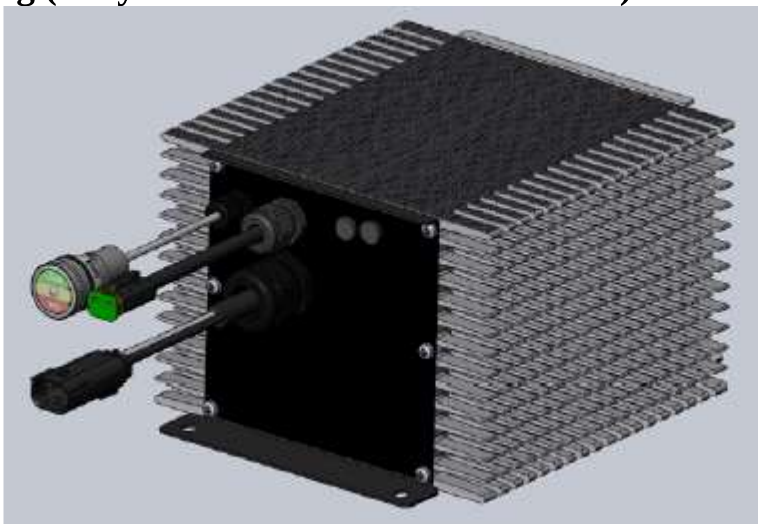
SECTION 7 – TRANSFORMER SHORT OR BURN-OUT

Failure of the transformer can be the result of natural aging, premature shorting of adjacent coil turns or overheating damage. The most common cause of transformer overheating and premature burn-out is the result of misuse, connecting the charger to a battery system of lower voltage than specified on the charger (see Section 3). Darkening of all the transformer secondary coil windings is an indication of possible overheating damage. A low or complete lack of output would be observed on the ammeter; however, the transformer may hum or the AC line fuse or circuit breaker may blow when the charger is turned on. To test the transformer, disconnect the power supply cord from its outlet and the DC output connector from the battery connector. Then disconnect the transformer secondary coil leads #1 and #4 from the diode terminals and disconnect the transformer capacitor coil leads from the capacitor terminals. Use care when disconnecting the capacitor lead so the wires do not break.

DANGER: HIGH VOLTAGE! WITH THE CHARGER OPERATING, THE CHARGER CAPACITOR VOLTAGE IS APPROXIMATELY 650 VOLTS AC. USE EXTREME CAUTION WHEN WORKING NEAR THE CAPACITOR TERMINALS.

In order to apply AC power directly to the transformer primary coil, the Electronic Timer Kit must be bypassed. Refer to Section 1, Part A, for bypass procedures. With the Electronic Timer Kit bypassed and taking care of personal safety, connect the power supply cord to an outlet. If the AC line fuse or circuit breaker blows, the transformer is shorted internally and must be replaced. If this does not occur, check the transformer secondary and capacitor coil voltages (Figure 1), using a suitable AC voltmeter. If the measured voltages are substantially lower than those shown, the transformer is shorted internally and must be replaced. If the transformer secondary coil voltage and capacitor coil voltage check good, disconnect the power supply cord from its outlet. Check the capacitor for correct rating, and then carefully reconnect the capacitor coil leads to the capacitor terminals. Then, taking care for personal safety, reconnect the power supply cord to an outlet and measure the transformer secondary voltage again. The correct voltage reading for a 36 VDC charger is shown in Figure 2. If the transformer secondary voltage is the same as measured with the capacitor disconnected, the capacitor may be opened, the capacitor coil may be open, or the capacitor coil terminals may not be making proper electrical contact. Refer to Section 1, Part C, Item 2, for capacitor test procedures. If the voltage readings are correct, both the transformer and capacitor are good, refer to Section 1, Part C, Item 1, for further tests of the DC circuit. If it should become necessary to replace a terminal on one of the transformer leads, the new terminal must be crimped AND soldered. NOTE: Some transformer leads may be aluminum wire and a solder must be used on these wires that is intended for use on aluminum, such as Alcoa #807 solder with Alcoa #69 flux.

3.4 Charging (Only for vehicles built after 1/11/10)



Charger Safety

The on-board charger can be plugged into every 2P+E 125V 15Amps (NEMA 5-15R) or 2P+E 230V 16A outlet, and therefore ends the need for a charge room. Before charging, the user will have to make sure that the chosen place for charging complies with required safety standards :

- Electric wiring must be conforming to National Electrical Code NFPA 70 or NF C 15100 standards, or must comply with standard regulation in activity inside the country to power mains supply. Presence of grounding (earth) wire and frame with proper ground-fault protection breaker is mandatory.
- The electric socket must be of type NEMA 5-15R 3 holes outlet 125V 15A or 2P+E, 230V 16A, correctly connected and protected by proper current-fault circuit breaker. Installation must comply with standard regulation in activity inside the country to power mains supply.
- Before charging, the state of connections and cables must be checked, and tightened if necessary.
- Charge to be made when the electric vehicle is off position.
- Charge has to proceed in a room without pollution and with sufficient ventilation.
- Charger must be mounted in its original location for adequate cooling.
- The charger is cooled by ambient air. The casing temperature does not exceed 65°C. Wait 30 minutes once charger has stopped before touching the casing or wear appropriate gloves.

Charger Operation

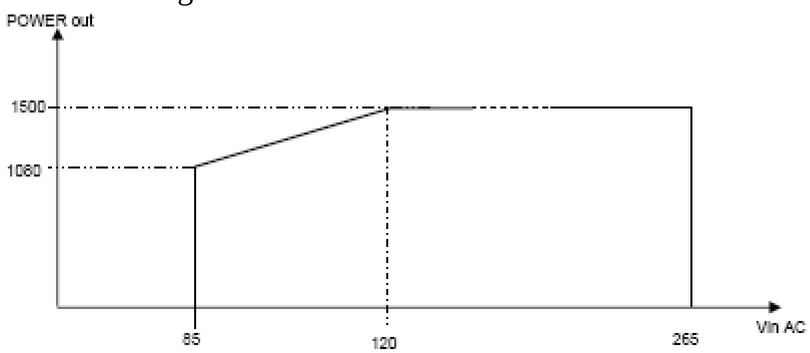
The battery charger is a self-regulating charger with a minimum of moving parts, designed for long, trouble free service. The charger utilizes convection cooling which maximizes the reliability and minimizes any maintenance costs.
Charge time will vary depending on the depth of discharge. Allow 8 hours for normal charging.

Charging Procedure

1. Connect the AC supply cord to the correct single phase outlet, located in the front bumper of the vehicle, with one of the proper voltages and frequencies as follows:

   Electrical specifications of charger

   Rated supply voltage : 85VAC to 138VAC and 195VAC to 265VAC
   Automatic AC Voltage Selection
   Mains frequency : 45/65Hz
   Inrush current: limited by NTC, Input current electronically limited (for low line) to 15Arms
   Max. output power: 1500W +/- 3%
   Max. output current : 21A +/- 2%
   Rated battery voltage : 72V
   Voltage tolerance at threshold U : 1%



2. The charger will start after a short delay as indicated by the light in the round display located through the front grill of the hood.

3. Through the grill of the hood in the front of the vehicle towards the driver's side there is a LED light that shows the state that the charger is in. Around this light is a sticker that looks like this diagram that explains what each of the three colors of the light mean:

   Red (20% battery charged)   Green (100% charged)
   Yellow (80% battery charged)   Off (No AC power is connected

4. Once the charge is completed the charger will turn off automatically. After the charger has turned off, disconnect the AC supply cord from the outlet.

5. Anti-Drive
   When a power cord is plugged into the front outlet of the vehicle and power is present the vehicle will power up but it will not move. In any case were AC power is still present at the front AC charger outlet make sure to have the park brake set and the ignition key turned off before you exit the vehicle. After the AC cord is disconnected from the front charger outlet, restart the vehicle and disengage the park brake and the vehicle will move.

6. Trickle charge

When the charger AC cord stays connected to the vehicle, a new charge cycle is triggered 24 hours after the end of the last charge cycle in order to compensate the auto-discharge.

7. Partial recharge
   The charger is designed to adapt automatically to all battery discharge states and allows all types of partial charge cycles or "opportunity charging". Meaning the vehicle can be charged at anytime no mater what the state of charge is.

Chargers Automatic Operations

- **Over lasting charge period**
  The charge cycle is interrupted when duration of phases I1+P+U1 exceed **16 hours**. This problem may occur if a battery element failed (short-circuit) or when ambient temperature is too high. Check the battery state.Return to normal state by disconnection of the mains for a few seconds, followed by its reconnection.

- **Mains power interruption**
  In case of temporary power cuts, all parameters of charge in progress are stored in memory for a period of **13 minutes**. As soon as power is back, the charge cycle continues from the point (I, P, U1, U2, Stop) attained just before power cut. The number of ampere-hours already charged has been stored in the memory of the microcontroller. If the power cut lasts more than 13 minutes, the charger assumes that the vehicle has been used and a complete charge cycle is started. It means, for restarting or resetting a new charging cycle, the mains must be disconnected at least **13 minutes**.

- **Protections against mains out of range:**
  I. If the mains voltage drops under the minimum allowed value (see specs), the charger automatically stops. It will automatically re-start as soon as the mains voltage comes back into the given tolerances. For low input voltage range, the charger will automatically reduce its output power to keep input current below 15A.
  II. If the mains voltage goes over the maximum allowed value (see specs), the charger automatically stops.
  III. Non significant over voltage: the charger will automatically re-start after about 20 seconds if mains voltage comes back into the given tolerances.
  IV. Significant over voltage: after about 1 minute, the charger will automatically try to re-start. If mains voltage does not come back into the given tolerances, the charger will stay in default state and will be able to re-start only after a mains disconnection (mains voltage in the given range).

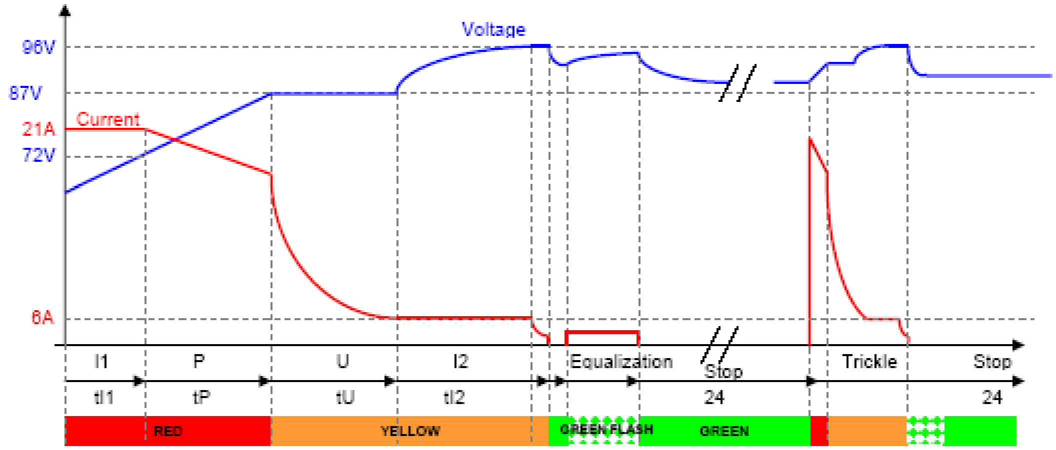
- **Thermal protection:**

The charger will automatically reduce its output power to maintain safe internal temperature and a maximum outside temperature of 65°C.

- **Charge Profile:**

Charging profile for Open Lead Flooded batteries 72V (max 260Ah) , selector position 3:

Progression of phases is **type I-U-I** as in diagram below :



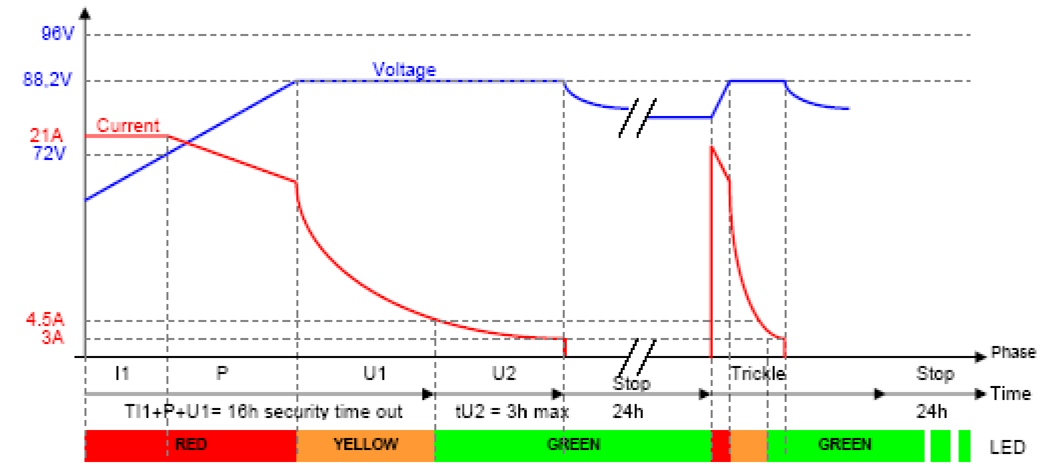
- The first phase **I1** at constant current (at maximum current) is maintained as long as battery voltage is under **72V**.
- The second phase **P** is the phase in which the charger output power is held constant, the current reduces slightly as battery voltage rises. The value of this power is equal to rated power of charger. This phase ends when battery voltage reaches **87V (2,42v/cell2)**.
- The **U** phase maintains the battery voltage at a constant value, the current accepted by the battery during this phase reduces progressively. The charger output voltage is limited to **87V (2,42v/cell)**. This phase ends when current reaches **6A**.
- The phase **I2** maintains the current about **6A** constant. This provides the boost necessary to correctly agitate the electrolyte.
- The duration of end phase **I2** is set to ensure that the charge quantity of this phase represents **12%** of charge injected during previous phases **I1-P-U** thus providing a boost coefficient of **1.12**. - I2 phase is voltage limited to **96V (2,67v/cell)**.

Equalizing charge (only for Open lead Battery)

- To eliminate the phenomenon of sulfatation and equalize all cells of the battery, this stage starts automatically after **every seven completed cycles**. Cycle duration must be superior to **4h** to be taken in account. The equalizing current is equal to half of the boost current value. This charge stops when battery voltage becomes stable (variation of less than **360mV / hour**) or after time out = **4h** which ever the first

Charging profile for AGM batteries 72V (max 260Ah), selector position 0:

Progression of phases is **type I-U** as in diagram below :



- The first phase **I1** has constant current. It is maintained as long as battery voltage is less than **72V**.

- The second phase **P** is the phase in which the charger output power is held constant, the current reduces slightly as battery voltage rises. The value of this power is equal to max allowed power of charger. This phase ends when battery voltage reaches the voltage threshold of **88,2V (2,45v/cell)**.

- The **U1** phase maintains the battery voltage at a constant voltage **88,2V (2,45v/cell)**. The current accepted by the battery during this phase reduces progressively. When the current is less than **4.5A**, the GREEN led turns ON, announcing to user that charge is almost completed. Then, the vehicle is usable with full performance.

- The **U2** phase finishes the Battery charging at a constant voltage **88,2V (2,45v/cell)**. The charger automatically turns off when the current reaches **3A** or after time out **= 3h** which ever the first. The Green Led remains ON during & after this phase.

- LED light is red during phases I1 and P (Bulk charge).
- LED light is yellow during phases U and I2.
- LED light is green flashing during cyclic equalization
- LED light is green when charger has completed charging batteries.
- LED light is off when main supply is switched off

Charging with different battery types

At the rear of the battery charger there are two rubber plugs. If you remove the rubber plug on the left side of the charger you will find a DIP switch. The switch has four settings to it which are all numbered 0-3. Each number correlates to a battery type.

Setting	Battery Type
Position 0:	AGM battery
Position 1:	GEL battery
Position 2:	Free (Open lead flooded battery by default)
Position 3:	OPEN lead flooded battery

Charging Battery Pack with Low Battery Pack Voltage

In most cases the battery charger will not turn on if the battery pack voltage gets lower than 20 volts. In this case each battery will need to be charged individually with a different battery charger.

<u>Vehicles equipped with an AC cab heater</u>

Note that vehicles equipped with an AC cab heater this charger is wired on the same inlet plug. This adds complications when diagnosing an issue. See Electrical Systems section under order of operations than 120 volt AC Heater (Vehicle built date after 1/11/10).

Chapter 4: Electrical Systems

***Note: This vehicle contains a high voltage electrical system. If this vehicle is not used properly or serviced as stated in this manual, serious injury or death may result.**

4.1 Electrical System Safety

4.1.1 Main Disconnect Switch

The main disconnect exists as a break in the ground cable from the main negative battery post of the battery pack to remove the power from the 72V system. This switch will kill power to the cabling in the rear of the vehicle, and in-turn the power to the 12V system on vehicles with the DC drive system. On AC drive equipped vehicles, also remove the fuse from the F5 location to kill power to the 12V system. This is very important to use when performing any kind of service on the vehicle's electrical system. It is very important to note; however, that this does not remove power from the cabling connecting the batteries to each other. This cabling is always live due to the nature of a battery.

4.1.2 Isolated Ground/Shock Danger

The vehicle electrical system operates with an isolated ground this keeps the chassis free from grounding and is a safety measure taken due to the presence of a high (72V) voltage system. This also makes the vehicle a more service safety friendly. The chassis not being grounded means that even if a metal object (such as a wrench) is placed from a live positive terminal to the chassis there <u>should</u> be no current. This can never be taken for granted however, there may be some circumstance that this is not true due to a service issue or state of disassembly due to a service operation. If a ground cable attached to a battery post is connected with the frame then the frame will be grounded and any positive voltage that comes in contact with the frame will energize it. Extreme caution should always be taken when working with the 72V system and <u>always</u> treat the connections as if they are very dangerous because most of the time they are. Voltage and amperage leakage from the battery pack to the chassis can be tested with a standard voltage test meter.

4.1.3 System Voltages

There are two main system voltages operating in the vehicle. The first is the 72V system which consists of the main drive power from the batteries to the controller and motor. This system is basically defined by the heavy gauge cabling found throughout the vehicle. This system carries a large supply of power at 72V and should be treated with great care when servicing or working around. Connection tightness and cleanliness in this system are very critical due to the power load carried. Loose connections could lead to damage components, loss of system efficiency and even fire and/or shock hazard.

The second main system voltage is the 12V system which is derived from the 72V system by means of a converter found attached to the firewall underneath the hood. This system is used to power all the accessories inside and outside the vehicle such as all lighting, dash display and most electrical optional components such as the dome light, heater, fan, and the alike. This system is completely isolated from the 72V system. It should be noted that there is also a 12V system that is powered from the controller for the controller operating systems. This system is not isolated from the 72V system. This non-isolated 12V system includes control systems for the controller feedback such as the speedometer readout (dash display), motor speed sensor, direction selector switch, park brake switch, regenerative brake switch and safety switch for the accelerator pedal. Apart from this small subset of the 12V system, the two 72V and 12V systems operate completely isolated from each other including their grounds.

4.2 Fuses

4.2.1 72 Volt Fuses

All 72 volt rated fuses are located in the rear motor compartment of the vehicle. In most cases, if these fuses fail there is another issue with your vehicle. Problems that cause fuse failure should be diagnosed by a trained professional.

Front Controls Fuse - This fuse is for the front controls of the vehicle (Ignition, converter, heater, etc). It is a 30 amp fuse (NON-30).

Main Drive System Fuse (DC Drive) - The main fuse for the 72 volt D.C. drive system which is rated for 325 amps (ANN-325).

Main drive System Fuse (AC Drive) - The main fuse for the 72 volt A.C. drive system which is rated for 425 amps (ANN-400) is mounted onto the A.C. drive controller.

4.2.2 12 Volt Fuses

The 12 volt fuses are located at the front of the vehicle beneath the hood. To access them, unlatch and open the hood and remove the aluminum tunnel cover. The fuse panel is a small black box in the center. Remove the weather cover by pressing both of the side tabs and lifting upward. The fuse circuit, size and panel locations are given in the following table:

Fuse Table

Fuse Location	Circuits Protected	Fuse
F1	Ignition	7.5 Amp
F2	Hazard & Turn Lights	10 Amp
F3	Radio	10 Amp
F4	Interior Dome Light	5 Amp
F5	12 Volt Battery (A.C. Drive only)	25 Amp
F6	Lithium BMS	5 Amp
F7	Fuel Fired Heater	20 Amp
F11	Headlights	20 Amp
F12	Horn, Backup Alarm, Backup light	15 Amp
F13	Brake Lights, Wiper Motor, 12 Volt Accessory Outlet	15 Amp
F14	Heater Coil, Heater Fan, Radio Ignition	10 Amp
F15	2-Speed Fan, Beacon Light	10 Amp
F17	Air Conditioner/Heater	20 Amp

Table 3: Fuse Table

4.3 Troubleshooting Flow Charts

All flow charts can be found online at http://www.e-ride.com/support.htm

4.4 Troubleshooting Controller Error Codes

4.4.1 DC Controller

The Curtis 1244 controller provides diagnostic information to assist in the troubleshooting of drive system problems. The diagnostic information can be obtained by observing the appropriate display on the handheld programmer or the fault codes issued by the Status LED.

The LED is built into the controller and is visible through a window in the label on top of the controller. The Status LED Displays fault codes when there is a problem with the controller or the inputs to the controller. During the normal operation, with no faults present, the Status LED flashes steadily on and off. If the controller detects a fault, a 2-digit fault identification code is flashed continuously until the fault is corrected. For example, code “3,2” appears as the following illustrated flash sequence.

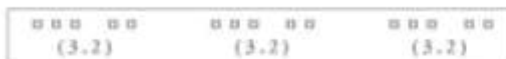


Figure 14: DC Controller Flash Sequence

The complete list of sequences and meanings are given in the following table.

STATUS LED FAULT CODES

LED CODES		EXPLANATION
LED off	▬▬▬	no power or defective controller
solid on	▭	controller or microprocessor fault
0,1	■ □	controller operational; no faults
1,1	□ □	[not used]
1,2	□ □□	hardware failsafe fault
1,3	□ □□□	M-, current sensor, or motor fault
1,4	□ □□□□	[not used]
2,1	□□ □	throttle fault
2,2	□□ □□	static return to off (SRO) fault
2,3	□□ □□□	high pedal disable (HPD) fault
2,4	□□ □□□□	emergency reverse circuit check fault
3,1	□□□ □	contactor driver overcurrent
3,2	□□□ □□	welded main contactor
3,3	□□□ □□□	precharge fault
3,4	□□□ □□□□	missing contactor, or main cont. did not close
4,1	□□□□ □	low battery voltage
4,2	□□□□ □□	overvoltage
4,3	□□□□ □□□	thermal cutback, due to over/under temp.
4,4	□□□□ □□□□	anti-tiedown fault

Table 4: DC Controller LED Fault Codes

The following table gives the troubleshooting scenarios for the controller faults and should be referenced for suggestions covering the wide range of faults.

TROUBLESHOOTING CHART

LED CODE	PROGRAMMER LCD DISPLAY	FAULT CATEGORY	EXPLANATION	POSSIBLE CAUSE
1,2	HW FAILSAFE1-2-3	1	self-test or watchdog fault	1. Controller defective.
1,3	M- SHORTED	1	internal M- short to B-	1. Controller defective.
	FIELD OPEN	1	field winding fault	1. Motor field wiring loose. 2. Motor field winding open.
	ARM SENSOR	1	armature current sensor fault	1. Controller defective.
	FLD SENSOR	1	field current sensor fault	1. Controller defective.
2,1	THROTTLE FAULT 1	1	wiper signal out of range	1. Throttle input wire open. 2. Throttle input wire shorted to B+ or B-.
	THROTTLE FAULT 2	1	pot low fault	1. Throttle pot defective. 2. Wrong throttle type selected.
2,2	SRO	3	SRO fault	1. Improper sequence of KSI, interlock, and direction inputs. 2. Wrong SRO type selected. 3. Interlock or direction switch circuit open. 4. Sequencing delay too short.
2,3	HPD	3	HPD fault	1. Improper seq. of direction and throttle inputs. 2. Wrong HPD type selected. 3. Misadjusted throttle pot. 4. Sequencing delay too short.
2,4	EB WIRING CHECK	1	emergency reverse wiring fault	1. Emergency reverse wire open. 2. Emergency reverse check wire open.
3,1	CONT DRVR OC	1	cont. driver output overcurrent	1. Contactor coil shorted.
3,2	MAIN CONT WELDED	1	welded main contactor	1. Main contactor stuck closed. 2. Main contactor driver shorted.
3,3	PRECHARGE FAULT	1	internal voltage too low at startup	1. Controller defective. 2. External short, or leakage path to B- on external B+ connection.
3,4	MISSING CONTACTOR	1	missing contactor	1. Any contactor coil open or not connected.
	MAIN CONT DNC	1	main contactor did not close	1. Main contactor missing or wire to coil open.
4,1	LOW BATTERY VOLTAGE	2	low battery voltage	1. Battery voltage <undervoltage cutback limit. 2. Corroded battery terminal. 3. Loose battery or controller terminal.
4,2	OVERVOLTAGE	2	overvoltage	1. Battery voltage >overvoltage shutdown limit. 2. Vehicle operating with charger attached. 3. Battery disconnected during regen braking.
4,3	THERMAL CUTBACK	2	over-/under-temp. cutback	1. Temperature >85°C or < -25°C. 2. Excessive load on vehicle. 3. Improper mounting of controller. 4. Operation in extreme environments.
4,4	ANTI-TIEDOWN	3	Mode 2 or Mode 4 selected at startup	1. Mode switches shorted to B+. 2. Mode switches "tied down" to select Mode 2 or Mode 4 permanently.

Table 5: DC Controller Troubleshooting Chart

4.4.2 AC Controller

The Curtis 1238 AC controller provides diagnostic information to assist in the troubleshooting of drive system problems in a similar fashion as the DC controller. The diagnostic information can be obtained by observing the appropriate display on the handheld programmer or the fault codes issued by the 2 Status LEDs. The pair of LEDs built into the controller (one red, one yellow) produce flash codes displaying all the currently set faults in a repeating cycle. Each code consists of two digits. The red LED flashes once to indicate that the first digit of the code will follow; the yellow LED then flashes the appropriate number of times for the first digit. The red LED flashes twice to indicate that the second digit of the code will follow; the yellow LED flashes the appropriate number of the times for the second digit. An example of the code for "Battery Under-Voltage" (code 23) is shown in the following flash sequence diagram.

Figure 15: AC Controller Flash Sequence

The LEDs have 4 different displays modes that indicate the type of information they are providing. These types are summarized in Table 6 below.

TYPES OF LED DISPLAY	
DISPLAY	STATUS
Neither LED illuminated	Controller is not powered on, has a dead battery, or is severely damaged.
Yellow LED flashing	Controller is operating normally.
Yellow and red LEDs both on solid	Controller is in Flash program mode.
Red LED on solid	Watchdog failure. Cycle KSI to restart.
Red LED and yellow LED flashing alternately	Controller has detected a fault. 2-digit code flashed by yellow LED identifies the specific fault; one or two flashes by red LED indicate whether first or second code digit will follow.

Table 6: AC Controller LED Display Types

The following troubleshooting chart (Table 7) provides the following information on all the controller faults including the ways to identify each fault, possible causes, and the "set" and "clear" conditions associated with each. Whenever a fault is encountered and no wiring or vehicle fault can be found, shut off the key switch and turn it back on to see if the fault clears. If not, shut off the key switch and remove the 35-pin connector to the controller. Check for connector corrosion or damage, clean it if necessary, and re-insert it.

TROUBLESHOOTING CHART

CODE	PROGRAMMER LCD DISPLAY / EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
12	*ShutdownMainContactor; ShutdownMotor; ShutdownEMBrake.*	1. External short of phase U,V, or W motor connections. 2. Motor parameters are mis-tuned. 3. Controller defective.	*Set:* Phase current exceeded the current measurement limit. *Clear:* Cycle KSI.
13	*ShutdownMainContactor; ShutdownMotor; ShutdownEMBrake.*	1. Leakage to vehicle frame from phase U, V, or W (short in motor stator). 2. Controller defective.	*Set:* Controller current sensors have invalid offset reading. *Clear:* Cycle KSI.
14	*ShutdownMainContactor; ShutdownMotor; ShutdownEMBrake.*	1. External load on capacitor bank (B+ connection terminal) that prevents the capacitor bank from charging. 2. See 1311 menu Monitor » Battery: Capacitor Voltage.	*Set:* Precharge failed to charge the capacitor bank to the KSI voltage. *Clear:* Cycle Interlock input or use VCL function Precharge().
15	*ShutdownMainContactor; ShutdownMotor; ShutdownEMBrake; ShutdownThrottle; FullBrake.*	1. Controller is operating in an extreme environment. 2. See 1311 menu Monitor » Controller: Temperature.	*Set:* Heatsink temperature below -40°C. *Clear:* Bring heatsink temperature above -40°C, and cycle interlock or KSI.
16	*ShutdownMainContactor; ShutdownMotor; ShutdownEMBrake; ShutdownThrottle; FullBrake.*	1. Controller is operating in an extreme environment. 2. Excessive load on vehicle. 3. Improper mounting of controller. 4. See 1311 menu Monitor » Controller: Temperature.	*Set:* Heatsink temperature above +95°C. *Clear:* Bring heatsink temperature below +95°C, and cycle interlock or KSI.
17	*Reduced drive torque.*	1. Battery Menu parameters are misadjusted. 2. Non-controller system drain on battery. 3. Battery resistance too high. 4. Battery disconnected while driving. 5. See 1311 menu Monitor » Battery: Capacitor Voltage. 6. Blown B+ fuse or main contactor did not close.	*Set:* Capacitor bank voltage dropped below the Severe Undervoltage limit (see page 55) with FET bridge enabled. *Clear:* Bring capacitor voltage above Severe Undervoltage limit.
18	*ShutdownMainContactor; ShutdownMotor; ShutdownEMBrake; ShutdownThrottle; FullBrake.*	1. Battery Menu parameters are misadjusted. 2. Battery resistance too high for given regen current. 3. Battery disconnected while regen braking. 4. See 1311 menu Monitor » Battery: Capacitor Voltage.	*Set:* Capacitor bank voltage exceeded the Severe Overvoltage limit (see page 55) with FET bridge enabled. *Clear:* Bring capacitor voltage below Severe Overvoltage limit, and then cycle KSI.
21	*None, unless a fault action is programmed in VCL.*	1. Controller is performance-limited at this temperature. 2. Controller is operating in an extreme environment. 3. See 1311 menu Monitor » Controller: Temperature.	*Set:* Heatsink temperature dropped below -25°C. *Clear:* Bring heatsink temperature above -25°C.

TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
22	*Reduced drive and brake torque.*	1. Controller is performance-limited at this temperature. 2. Controller is operating in an extreme environment. 3. Excessive load on vehicle. 4. Improper mounting of controller. 5. See 1311 menu Monitor » Controller: Temperature.	*Set:* Heatsink temperature exceeded 85°C. *Clear:* Bring heatsink temperature below 85°C.
23	*Reduced drive torque.*	1. Normal operation. Fault shows that the batteries need recharging. Controller is performance limited at this voltage. 2. Battery parameters are misadjusted. 3. Non-controller system drain on battery. 4. Battery resistance too high. 5. Battery disconnected while driving. 6. See 1311 menu Monitor » Battery: Capacitor Voltage. 7. Blown B+ fuse or main contactor did not close.	*Set:* Capacitor bank voltage dropped below the Undervoltage limit (see page 55) with the FET bridge enabled. *Clear:* Bring capacitor voltage above the Undervoltage limit.
24	*Reduced brake torque.*	1. Normal operation. Fault shows that regen braking currents elevated the battery voltage during regen braking. Controller is performance limited at this voltage. 2. Battery parameters are misadjusted. 3. Battery resistance too high for given regen current. 4. Battery disconnected while regen braking. 5. See 1311 menu Monitor » Battery: Capacitor Voltage.	*Set:* Capacitor bank voltage exceeded the Overvoltage limit (see page 55) with the FET bridge enabled. *Clear:* Bring capacitor voltage below the Overvoltage limit.
25	*None, unless a fault action is programmed in VCL.*	1. External load impedance on the +5V supply (pin 26) is too low. 2. See 1311 menu Monitor » outputs: 5 Volts and Ext Supply Current.	*Set:* +5V supply (pin 26) outside the +5V±10% range. *Clear:* Bring voltage within range.
26	*Digital Output 6 driver will not turn on.*	1. External load impedance on Digital Output 6 driver (pin 19) is too low.	*Set:* Digital Output 6 (pin 19) current exceeded 15 mA. *Clear:* Remedy the overcurrent cause and use the VCL function Set_DigOut() to turn the driver on again.
27	*Digital Output 7 driver will not turn on.*	1. External load impedance on Digital Output 7 driver (pin 20) is too low.	*Set:* Digital Output 7 (pin 20) current exceeded 15 mA. *Clear:* Remedy the overcurrent cause and use the VCL function Set_DigOut() to turn the driver on again.

TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY / EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
28	*Reduced drive torque.*	1. Motor temperature is at or above the programmed Temperature Hot setting, and the requested current is being cut back. 2. Motor Temperature Control Menu parameters are mis-tuned. 3. See 1311 menus Monitor » Motor: Temperature and Monitor » Inputs: Analog2. 4. If the application doesn't use a motor thermistor, Temp Compensation and Temp Cutback should be programmed Off.	*Set:* Motor temperature is at or above the Temperature Hot parameter setting. *Clear:* Bring the motor temperature within range.
29	*MaxSpeed reduced (LOS, Limited Operating Strategy) and motor temperature cutback is disabled.*	1. Motor thermistor is not connected properly. 2. If the application doesn't use a motor thermistor, Temp Compensation and Temp Cutback should be programmed Off. 3. See 1311 menus Monitor » Motor: Temperature and Monitor » Inputs: Analog2.	*Set:* Motor thermistor input (pin 8) is at the voltage rail (0 or 10V). *Clear:* Bring the motor thermistor input voltage within range.
31	*ShutdownDriver1.*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set:* Driver 1 (pin 6) is either open or shorted. *Clear:* Correct open or short, and cycle driver.
31	*ShutdownDriver1; ShutdownMotor; ShutdownEMBrake.*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set:* Main contactor driver (pin 6) is either open or shorted. *Clear:* Correct open or short, and cycle driver.
32	*ShutdownDriver2.*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set:* Driver 2 (pin 5) is either open or shorted. *Clear:* Correct open or short, and cycle driver.
32	*ShutdownDriver2; ShutdownThrottle; FullBrake.*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set:* Electromagnetic brake driver (pin 5) is either open or shorted. *Clear:* Correct open or short, and cycle driver.
33	*ShutdownDriver3.*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set:* Driver 3 (pin 4) is either open or shorted. *Clear:* Correct open or short, and cycle driver.
34	*ShutdownDriver4.*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set:* Driver 4 (pin 3) is either open or shorted. *Clear:* Correct open or short, and cycle driver.
35	*ShutdownPD.*	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or faulty wiring.	*Set:* Proportional driver (pin 2) is either open or shorted. *Clear:* Correct open or short, and cycle driver.
36	*Control Mode changed to LOS (Limited Operating Strategy).*	1. Motor encoder failure. 2. Bad crimps or faulty wiring. 3. See 1311 menu Monitor » Motor: Motor RPM.	*Set:* Motor encoder phase failure detected. *Clear:* Cycle KSI.

TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY / EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
37	*ShutdownMainContactor; ShutdownMotor; ShutdownEMBrake.*	1. Motor phase is open. 2. Bad crimps or faulty wiring. 3. Bad crimps or faulty wiring.	*Set:* Motor phase U, V, or W detected open. *Clear:* Cycle KSI.
38	*ShutdownMainContactor; ShutdownMotor; ShutdownEMBrake.*	1. Main contactor tips are welded closed. 2. Motor phase U is disconnected or open. 3. An alternate voltage path (such as an external precharge resistor) is providing a current to the capacitor bank (B+ connection terminal).	*Set:* Just prior to the main contactor closing, the capacitor bank voltage (B+ connection terminal) was loaded for a short time and the voltage did not discharge. *Clear:* Cycle KSI
39	*ShutdownMainContactor; ShutdownMotor; ShutdownEMBrake.*	1. Main contactor did not close. 2. Main contactor tips are oxidized, burned, or not making good contact. 3. External load on capacitor bank (B+ connection terminal) that prevents capacitor bank from charging. 4. Blown B+ fuse.	*Set:* With the main contactor commanded closed, the capacitor bank voltage (B+ connection terminal) did not charge to B+. *Clear:* Cycle KSI.
41	*ShutdownThrottle.*	1. Throttle pot wiper voltage too high. 2. See 1311 menu Monitor » Inputs: Throttle Pot.	*Set:* Throttle pot wiper (pin 16) voltage is higher than the high fault threshold (can be changed with the VCL function Setup_Pot_Faults()). *Clear:* Bring throttle pot wiper voltage below the fault threshold.
42	*ShutdownThrottle.*	1. Throttle pot wiper voltage too low. 2. See 1311 menu Monitor » Inputs: Throttle Pot.	*Set:* Throttle pot wiper (pin 16) voltage is lower than the low fault threshold (can be changed with the VCL function Setup_Pot_Faults()). *Clear:* Bring throttle pot wiper voltage above the fault threshold.
43	*FullBrake.*	1. Brake pot wiper voltage too high. 2. See 1311 menu Monitor » Inputs: Brake Pot.	*Set:* Brake pot wiper (pin 17) voltage is higher than the high fault threshold (can be changed with the VCL function Setup_Pot_Faults()). *Clear:* Bring brake pot wiper voltage below the fault threshold.
44	*FullBrake.*	1. Brake pot wiper voltage too low. 2. See 1311 menu Monitor » Inputs: Brake Pot.	*Set:* Brake pot wiper (pin 17) voltage is lower than the low fault threshold (can be changed with the VCL function Setup_Pot_Faults()). *Clear:* Bring brake pot wiper voltage above the fault threshold.
45	*ShutdownThrottle; FullBrake.*	1. Combined pot resistance connected to pot low is too low. 2. See 1311 menu Monitor » Outputs: Pot Low.	*Set:* Pot low (pin 18) current exceeds 10mA. *Clear:* Clear pot low overcurrent condition and cycle KSI.

TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
46	*ShutdownMainContactor; ShutdownMotor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake.*	1. Failure to write to EEPROM memory. This can be caused by EEPROM memory writes initiated by VCL, by the CAN bus, by adjusting parameters with the 1311, or by loading new software into the controller.	*Set:* Controller operating system tried to write to EEPROM memory and failed. *Clear:* Download the correct software (OS) and matching parameter default settings into the controller and cycle KSI.
47	*ShutdownThrottle.*	1. KSI, interlock, direction, and throttle inputs applied in incorrect sequence. 2. Faulty wiring, crimps, or switches at KSI, interlock, direction, or throttle inputs. 3. See 1311 menu Monitor » Inputs.	*Set:* HPD (High Pedal Disable) or sequencing fault caused by incorrect sequence of KSI, interlock, direction, and throttle inputs. *Clear:* Reapply inputs in correct sequence.
47	*ShutdownThrottle; ShutdownEMBrake.*	1. Emergency Reverse operation has concluded, but the throttle, forward and reverse inputs, and interlock have not been returned to neutral.	*Set:* At the conclusion of Emergency Reverse, the fault was set because various inputs were not returned to neutral. *Clear:* If EMR_Interlock = On, clear the interlock, throttle, and direction inputs. If EMR_Interlock = Off, clear the throttle and direction inputs.
49	*ShutdownMainContactor; ShutdownMotor; ShutdownEMBrake.*	1. This is a safety fault caused by a change in certain 1311 parameter settings so that the vehicle will not operate until KSI is cycled. For example, if a user changes the Throttle Type this fault will appear and require cycling KSI before the vehicle can operate.	*Set:* Adjustment of a parameter setting that requires cycling of KSI. *Clear:* Cycle KSI.
51–67	*(See OEM documentation.)*	1. These faults can be defined by the OEM and are implemented in the application-specific VCL code. See OEM documentation.	*Set:* See OEM documentation. *Clear:* See OEM documentation.
68	*ShutdownMainContactor; ShutdownMotor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake.*	1. VCL code encountered a runtime VCL error. 2. See 1311 menu Monitor » Controller: VCL Error Module and VCL Error. This error can then be compared to the runtime VCL module ID and error code definitions found in the specific OS system information file.	*Set:* Runtime VCL code error condition. *Clear:* Edit VCL application software to fix this error condition; flash the new compiled software and matching parameter defaults; cycle KSI.

TROUBLESHOOTING CHART, continued

CODE	PROGRAMMER LCD DISPLAY / EFFECT OF FAULT	POSSIBLE CAUSE	SET/CLEAR CONDITIONS
69	*None, unless a fault action is programmed in VCL.*	1. External load on the 5V and 12V supplies draws either too much or too little current. 2. Fault Checking Menu parameters Ext Supply Max and Ext Supply Min are mis-tuned. 3. See 1311 menu Monitor » Outputs: Ext Supply Current.	*Set:* The external supply current (combined current used by the 5V supply [pin 26] and 12V supply [pin 25]) is either greater than the upper current threshold or lower than the lower current threshold. The two thresholds are defined by the Ext Supply Max and Ext Supply Min parameter settings (page 52). *Clear:* Bring the external supply current within range.
71	*ShutdownMainContactor; ShutdownMotor; ShutdownEMBrake; ShutdownThrottle; ShutdownInterlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownPD; FullBrake.*	1. Internal controller fault.	*Set:* Internal controller fault detected. *Clear:* Cycle KSI.
72	*ShutdownInterlock; CAN NMT State set to Pre-operational.*	1. Time between CAN PDO messages received exceeded the PDO Timeout Period.	*Set:* Time between CAN PDO messages received exceeded the PDO Timeout Period. *Clear:* Cycle KSI.
73	*Control Mode changed to LOS (Limited Operating Strategy).*	1. Stalled motor. 2. Motor encoder failure. 3. Bad crimps or faulty wiring. 4. Problems with power supply for the motor encoder. 5. See 1311 menu Monitor » Motor: Motor RPM.	*Set:* No motor encoder movement detected. *Clear:* Either cycle KSI, or detect valid motor encoder signals while operating in LOS mode and return Throttle Command = 0 and Motor RPM = 0.
87	*ShutdownMainContactor; ShutdownThrottle; ShutdownEMBrake; ShutdownMotor.*	1. Motor characterization failed because of an Overvoltage or Undervoltage fault, Motor Temperature Sensor fault, or Motor_Temperature > 150°C during the characterization process.	*Set:* Motor characterization failed during the motor characterization process. *Clear:* Cycle KSI.
88	*ShutdownMainContactor; ShutdownThrottle; ShutdownEMBrake; ShutdownMotor Encoder_Steps set to value -31.*	1. Encoder characterization failed during the motor characterization process. 2. Motor encoder pulse rate is not a standard value (32, 48, 64, 80 ppr).	*Set:* During the motor characterization process, encoder pulses were detected but the Encoder_Steps were not detected as 32, 48, 64, or 80 ppr. *Clear:* Manually set Encoder_Steps to the correct value for the motor encoder and cycle KSI.

Table 7: AC Controller Troubleshooting Chart

4.5 Theory of operations (2008-2010 EXV2 & EXV4 models only)

Charger (Vehicle built date before 1/12/10)

The vehicle is charged by simply plugging in either a 110 volt 16 amp or 220 volt 13 amp power sources to one of the charger inlet plugs in the front bumper of the vehicle. The AC power goes straight to the charger which is mounted in the rear of the vehicle just behind and above the rear axle. The main battery disconnect must be on to charge the vehicle. If both AC power of 85 volts or higher and DC power of 35 volts of higher is present at the charger it will turn on and automatically charge the vehicle. Amount of amperage supplied to the batteries is dependant on the state of charge. When the battery voltage stops increasing .0124 volts in 30 minuets the charger will shut off. Normally the voltage should reach 90-94 volts before the charger will shut off. If the voltage increases above .0124 volts in 30 minuets and the charger shuts off then the timer board in the charger is bad. But if the voltage does not increase .0124 volts in 30 minuets and the battery pack voltage does not get to at least 90 volts before the charger shuts off then you have an issue with a battery or battery pack.

Charger (Vehicle built date after 1/12/10)

The vehicle is charged by simply plugging in either 85-138 or 195-265 volts AC 1500 watt power source to the charger inlet plug in the front bumper of the vehicle. The AC power goes straight to the charger which is mounted in the front of the vehicle inside the battery tunnel under the hood. The main battery disconnect must be on to charge the vehicle. If both AC power of 85 volts or higher and DC power of 20 volts of higher is present at the charger it will turn on and automatically charge the vehicle. Amount of amperage supplied to the batteries is dependant on the state of charge.

Ignition

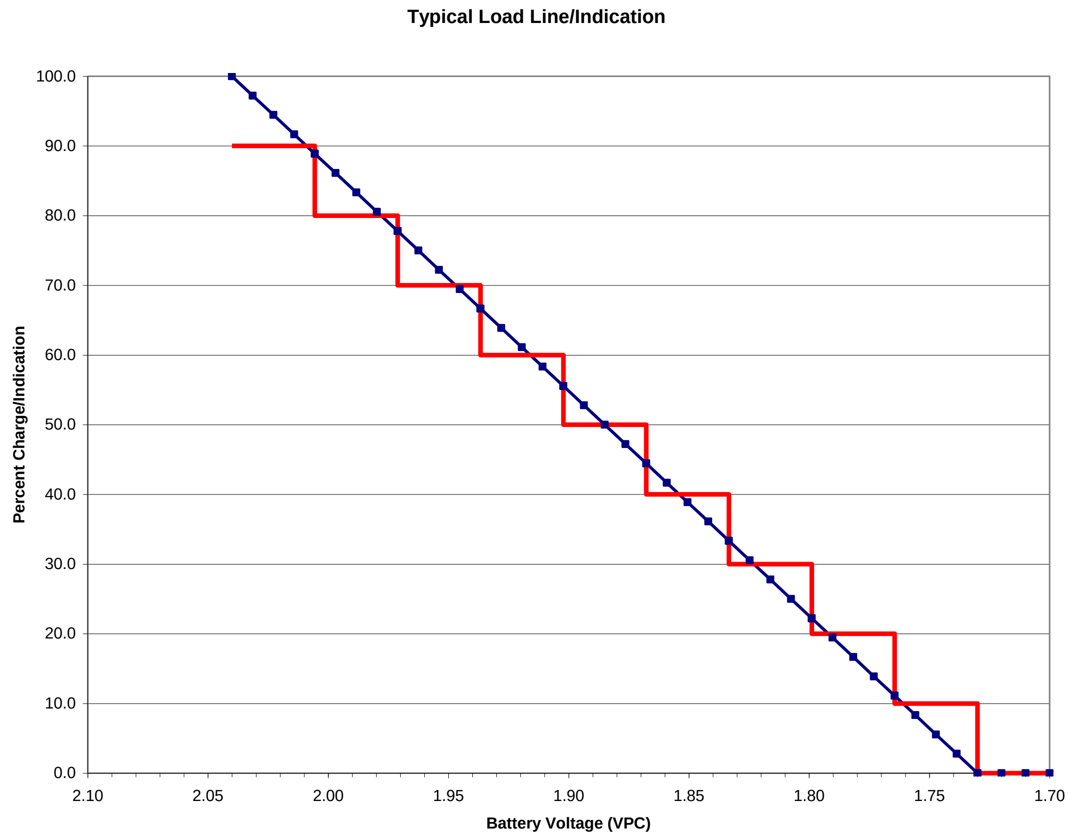
Battery pack positive power goes through a 30 amp fuse mounted in the rear driver's side of the vehicle. This power runs up the battery tunnel and supplies power to the DC/DC converter, ignition relay, digital dash display and heater. The DC/DC converter is powered when ever the main battery disconnect is on and the pack voltage is above 57 volts. It reduces the pack voltage to a steady 13.5 volts with a max output of 30 amps and 25 amps cont. The DC/DC converter supplies power to the fuse panel. F1-F10 fuses are always live. F11-F20 fuses are live only when the ignition key is turned on. The power going through the F1 fuse supplies power to the ignition switch. When the ignition switch closes power goes to the ignition relay and to the switch input of the DC/DC converter which closes a relay inside the DC/DC converter which in turn powers F11-F20 fuses. When the key is turned on the ignition relay is closed. The ignition relay supplies pack voltage to the speed controller, accel pedal, digital dash display, battery water level float switch, main contactor and three relays behind the dash.

Digital Dash Display

Positive pack voltage is supplied to pin# 1 all the time. Negative pack voltage is supplied to pin# 2, 17 & 3(DC drive only) when ever the main battery disconnect is turned on. When the ignition key is turned on pack voltage goes through the ignition relay and supplies positive power to pin# 13 (ignition) & 19 (internal heater). The display is designed for multiple voltages and speedometer settings. Negative pack voltage needs to be supplied to pin #17 when the display is powered up or else it will go into the incorrect voltage setting giving you an inaccurate state of charge reading. On DC drive vehicles negative pack voltage needs to be supplied to pin# 3 when display is first powered up or else it can go into the incorrect speed mode as a result showing no speed all the time. When every power is supplied to pin# 13 the hour meter on the display is counting. When every power is supplied to pin# 1 the clock is always counting.

The digital dash display monitors battery state of charge by monitor the battery pack voltage over a long period of time and makes decisions based on this information. This is depicted on a straight load line as a dot on the line of the graph below. After a set number of preset decrement actions (four in the example below) the gage commands the display to turn off the top bar now representing 90% state of charge. This sequence continues as the battery continues to discharge until the gage runs down to the bottom-most bar at which point in addition to the display flashing the caution symbol on the display lights up. As soon as the battery pack voltage drops below 73.44 volts (which in most cases is achieved when the batteries are loaded) it starts taking voltage readings and then averages the voltage readings giving you a state of charge from that. 73.44 volts is 100% state of charge and 62.28 volts is 0% state of charge. This gauge is equipped with CTR (Charge Tracking Reset) which gives it the ability to integrate in reverse and keep track of a system that utilizes opportunity charging. In this case the state of charge will increase when ever the pack voltage is above 75.6 volts. It works in the same manner as described above and on the graph below but in reverse. If at any time the battery pack voltage reaches 84.6 volts the state of charge gauge will reset to 100% state of charge. This does not mean that the vehicle is fully charged. In any case were the main battery disconnect has been cycled the gauge uses OCR (Open Circuit Reset) so at any time the main battery disconnect is turned back on and the battery pack voltage is greater than 75.24 volts at the time the main disconnect was reconnected the gage would reset to 100% state of charge.

The staircase shaped line represents the 10 bar indication of the gage. Battery voltage is displayed as volts per cell. There are 36 cells in your battery bank. Multiply VPC (volts per cell) by 36 to get battery pack voltage.



The speedometer on the digital dash display accepts a pulsed input on pin# 5 that comes from the motor. The DC drive motor supplies 8 pulses per motor revolution. This sensor is a hall-affect. The AC drive motor supplies 64 pulses per motor revolution. This sensor is an encoder. The DC drive speed sensor is powered by 12 volts supplied by the speed controller. The AC drive encoder is powered by 5 volts supplied by the speed controller. When ever a pulsed signal goes to pin# 5 the display is counting miles and adding them to the odometer.

All other inputs such as turn signal, brights, park brake and battery water level symbols all light up when pack voltage is present at pin# 8(park brake), #9(left turn), #10(right turn), #11(high beam) & #7(battery water level low).

Accel Pedal (Vehicle built date before 12/23/08)

The accel pedal safety switch is powered when ever the ignition key is on. The common side of the switch is pin# F and the switched side is pin# D. When the ignition key is on it turns on the speed controller and the controller supplies 12 volts positive to the common side of the accel pedal safety switch. When the accel pedal is pressed down slightly the switch closes sending 12 volts positive power to the speed controller.

The accel pedal potentiometer is powered when ever the ignition key is on. Positive goes to pin# C which is 5 volt positive and negative goes to pin# B which both are from the speed controller. When the ignition switch is turned on it closes the ignition relay. The ignition relay supplies pack voltage positive power to the accel pedal potentiometer. The ignition relay also powers up the speed controller which than supplies ground to the negative side of the potentiometer switch. The accel pedal potentiometer than gives out a positive voltage out of pin# A of the accel pedal. This voltage can be from 0-5 volts positive depending on the percentage the accel pedal is pressed. In most cases at zero percentage of throttle the accel pedal potentiometer is supplying .8 volts to the controller. The max it usually supplies to the controller at full throttle is about 3.8 volts.

Accel Pedal (Vehicle built date after 12/22/08)

The accel pedal safety switch is powered when ever the ignition key is on. The common side of the switch is pin# E and the switched side is pin# D. When the ignition key is on it turns on the speed controller and the controller supplies 12 volts positive to the common side of the accel pedal safety switch. When the accel pedal is pressed down slightly the switch closes sending 12 volts positive power to the speed controller.
The accel pedal potentiometer is powered when ever the ignition key is on. Positive goes to pin# A which is from Positive on battery pack (note some vehicles were equipped with a resistor which would drop this voltage reading 8 volts from pack voltage) and negative goes to pin# C which is from the speed controller. When the ignition switch is turned on it closes the ignition relay. The ignition relay supplies pack voltage positive power to the accel pedal potentiometer. The ignition relay also powers up the speed controller which than supplies ground to the negative side of the potentiometer switch. The accel pedal potentiometer than gives out a positive voltage out of pin# B of the accel pedal. This voltage can be from 0-5 volts positive depending on the percentage the accel pedal is pressed. In most cases at zero percentage of throttle the accel pedal potentiometer is supplying .2 volts to the controller. The max it usually supplies to the controller at full throttle is about 4 volts.

72 volt DC Heater

The 72 volt DC heater element is mounted inside the center console. Power for the heater is supplied to the center console when ever the main battery disconnect is turned on. Positive pack voltage enters the console at pin# 5. Negative pack voltage is at pin# 2. Mounted to the top of the heater is a contactor. This contactor opens/closes the positive power circuit going to the heating element. This contactors coil power is 12 volts. The 12 volt power comes from the DC/DC converter. When the ignition key is turned on the 12 volt power exits the DC/DC converter at pin# 7&8 and goes to the Fuse panel. Power goes through panel and exits at fuse F14 then goes to the center console at pin# 7. After entering the center console it goes to pin# 2 of the heater switch. When the heater switch is closed the power lights up the light inside the switch and also exits the switch at pin# 3. This power goes to the contactor and the low speed of the blower for the heater. When the contactor closes it supplies the 72 volt heater with positive pack voltage. At the same time the low speed of the blower should turn on. Negative power is supplied to the heater switch at pin# 7. This negative 12 volt powers the light inside the switch. Negative power is present when ever the main battery disconnect is turned on.

120 volt AC Heater (Vehicle built date before 1/12/10)

The 120 volt AC heater element is mounted inside the center console. In most cases it will be installed next to 72 volt DC heater. The 120 volt AC heater is powered when ever an AC power source is present at the outlet mounted on the exterior of the vehicle and the switch next to the outlet is in the up position. Ground from the AC heater plug is run throughout the chassis of the vehicle. Neutral is run to pin# 11 of the center console plug then it goes to the 120 volt heater element terminal #'s 1,3 & 5 and the AC/DC inverter. Hot is run through the switch to pin# 12 of the center console connector and then to 120 volt heater element terminal #'s 2 & 4 and the AC/DC inverter. The AC/DC inverter supplies power to the 12 volt blower fan. When 120 volt AC power is present on the input side of the AC/DC inverter the output side supplies 12 volts DC to the heater fan blower. Only high speed is used on the blower. The AC/DC inverter can handle up to a 5 amp draw.

120 volt AC Heater (Vehicle built date after 1/11/10)

The 120 volt AC heater element is mounted inside the center console. In most cases it will be installed next to 72 volt DC heater. The 120 volt AC heater is powered when ever an AC power source is present at the battery charger inlet plug mounted at the front bumper and the AC heater switch mounted on the center console is turned on and then momentarily pressed to the start position. Ground from the AC heater plug is run throughout the chassis of the vehicle. Neutral is run to pin#2 of the sealed three pin center console plug then it goes to the 120 volt heater element terminal #'s 1,3 & 5, the AC/DC inverter and pin# . Hot is run through the switch to pin# 1 of the center console sealed three pin connector and then to pin# 3 (Common) of the front 120 volt relay mounted on the heater box, pin# 1 (Coil) on the rear 120 volt relay and pin#5 of the AC heater switch. When the 120 volt heater button is pressed to the start position it sends power to the front 120 volt relay pin#2. The relay closes and sends power out pin#4 to the 120 volt heater element terminal #'s 2 & 4, the AC/DC blower inverter and the pin#2 of the AC heater switch. When the heater switch is in the on position it keeps the power going to pin#2 (Coil) of the front relay keeping it closed until the switch is turned to off. When the switch is off the front relay is open but then it sends power out pin# 5 through pin# 3 of the three pin center console sealed connector to the hot inlet side of the battery charger.

The AC/DC inverter supplies power to the 12 volt blower fan. When 120 volt AC power is present on the input side of the AC/DC inverter the output side supplies 12 volts DC to the heater fan blower. Only high speed is used on the blower. The AC/DC inverter can handle up to a 5 amp draw.

The rear 120 volt relay mounted on the heater box is for anti-drive. When ever 120 volt AC power is present and the front bumper battery charger inlet plug the relay is closed between pin #'s 3 & 5. In this case the two pin sealed anti-drive connector on the battery charger will be removed from the wires on the charger and the terminals will have heat shrink on them. The two wires going to pin #3 & 5 of the relay will be connected to were the anti-drive of the battery charger usually hooks up.

Heater Fan

The heater fan is powered by the heater switch at heater fan switch. When the ignition key is turned on the 12 volt power exits the DC/DC converter at pin# 7&8 and goes to the Fuse panel. Power goes through panel and exits at fuse F14 then goes to the center console at pin# 7. After entering the center console it goes to pin# 2 of the heater switch. When the heater switch is closed the power lights up the light inside the switch and also exits the switch at pin# 3. This powers the low speed of the fan. It has an inline diode so power can not enter the switch pin# 3 when the medium or high speeds of the fan switch are selected. The same 12 volt power at pin# 7 of the center console powers the heater fan switch. This 12 volt power enters the switch at pin# 5. This switch is located right beside the heater switch. Switch is off when in the down position. When the switch is positioned in the middle spot 12 volt power exits the switch at pin# 4 and reenters the switch at pin# 2 and then back out at pin# 3. This power than goes to the medium speed of the heater blower fan. When the switch is positioned in the top location 12 volt power exits the switch at pin# 6. This power than goes to the high speed of the heater blower fan.

Two speed fan

The two speed fan is powered by the Aux. fan switch. When the ignition key is turned on the 12 volt power exits the DC/DC converter at pin# 7&8 and goes to the Fuse panel. Power goes through panel and exits at fuse F15 then goes to the center console at pin# 8. After entering the center console it goes to pin# 5 of the Aux. fan switch. Switch is off when in the down position. When the switch is positioned in the middle spot 12 volt power exits the switch at pin# 4 and reenters the switch at pin# 2 and then back out at pin# 3. This power than goes to the medium speed of the aux. fan. When the switch is positioned in the top location 12 volt power exits the switch at pin# 6. This power than goes to the high speed of the aux. fan.

DC/DC Converter

The DC/DC converter is mounted underneath the front hood attached to the firewall. It is powered when ever the main battery disconnect is on. It gets its power from the main battery pack and converts the pack voltage to 12-13.5 volts. Positive power goes from the positive post of the rear battery through the 30 amp aux. fuse and than into pin# 12 of the DC/DC converter. Negative power goes from the negative post of the front battery through the main battery disconnect and then into pin# 1 of the DC/DC converter. The DC/DC converter supplies 12 volt positive power to the fuse panel located under the front tunnel cover out pin locations 7,8,9 & 10. Pin# 9 & 10 are live when ever the main battery disconnect is turned on. Pin# 7 & 8 are live only when the ignition key is tuned on. When the ignition key is turned on it supplies power to pin# 3 of the DC/DC converter. This closes the internal relay when makes pin# 7 & 8 live. The pin# 4, 5 & 6 of the DC/DC converter supply the 12 volt negative power to all 12 volt components. These wires are live when ever the main battery disconnect is turned on. Note: The chassis of the vehicle is totally isolated. Also that the DC/DC converter can not convert power from pack voltage to 12 volts if the pack voltage is below 57 volts.

Refuse Dump Box

The dump box runs on its own separate 12 volt battery charged by its own separate 12 volt 6 amp battery charger. When 120 volt AC power is present at the dump box receptacle the charger will automatically start up if the battery needs to be charged and then automatically shut off once the battery is fully charged. See dump box wiring diagram from instructions on how your dump box works.

The dump box is equipped with a safety switch so that at any time when the dump box is raised the vehicle will not drive. The safety switch is wired to the main contactor coiling wires. Pack voltage is supplied to the common side of the dump box switch.

When the switch is pressed pack voltage exits the switch and goes to the coiling side of the safety switch. Note: Contactor error codes will be present if the dump box switch is open when the ignition key is on.

Dome Light

The interior dome light is powered by the 12 volt fuse panel F4 location. Ground runs to pin# 4,5 & 6 of the DC/DC converter. When ever the main battery disconnect is turn on power is supplied to the interior light. The interior light has a switch mounted on it. When the switch is pushed once the switch will closed as a result the light will turn on. Press the switch again and the light will go off.

Beacon

The beacon light is powered by the 12 volt fuse panel F4 location. Ground runs to pin# 4,5 & 6 of the DC/DC converter. When ever the main battery disconnect is turn on power is supplied to the interior light. The interior light has a switch mounted on it. When the switch is pushed once the switch will closed as a result the light will turn on. Press the switch again and the light will go off.

Solar Panels

The solar panels mounted to the top of the vehicle produce a variation of power. In most cases depending on the system the max power they produce is 30 volts at 13.3 amps totaling 400 watts. All the positive connections are tied together and all the negative connections are tied together. The positive and negative wires run to the solar charge controller mounted behind the dash on the passenger's side. This charger controller monitors the amount of charge going to the main battery pack. 30 volts enter the charge controller and 72-94 volts exits the charge controller. The positive output side of the charge controller is fused with an inline 10 amp replaceable fuse and is wired to the positive post of the rear battery in the battery pack. The negative output side of the charger controller is wired to the main battery disconnect which in turn goes to the negative side of the front battery in the battery pack. The solar panels will only charge the battery pack when the main battery disconnect is turned on.

Battery Warmer

The battery warmer is a 500 watt 120 volt heating pad located under the battery pack. It runs the entire length and width of the battery pack. When ever 120 volt AC power is present at the battery warmer receptacle the heater element will power up. There is a thermostat mounted to the side of the fifth battery. This thermostat monitors the battery temperature. The thermostat opens at 80 deg. F and closes at 60 deg. F. Ground from the AC receptacle is run throughout the chassis of the vehicle.

Brake Light Switch/turn signal/hazard/regen relay

The brake light switch is located on the rear outlet port of the brake master cylinder or online of one of the brake lines inside the front battery tunnel. 12 volts positive power runs from fuse F13 to the brake light switch only when the ignition key is on and when brake pressure is present the switch closes sending power to the coiling side of the brake relay pin# 86 located inside the battery tunnel (AC Drive Only) than through an inline 6 amp diode to pin# P of the steering column. Power is then sent out pin# N & M of the steering column to the rear brake lights. If at any time the turn signal is on the direction turned on the brakes lights will not come on for that side. Ground is supplied to the rear brake lights through pin# 4, 5 & 6 of the DC/DC converter.

The brake relay is to let the AC drive controller know when the brakes are being applied so it can increase the amount of regen braking. The brake relay has negative 12 volts present to pin# 85 coming from pin# 4,5 & 6 of the DC/DC converter when ever the main battery disconnect is turned on. When the brake pressure is present and the brake switch closes it sends power to pin# 86 of the brake relay which closes the circuit in the relay. Pin# 30 is the common terminal for the internal contacts. Pin# 30 has 12 volts supplied to it from the speed controller when ever the ignition key is turned on. When the relay closes the controller’s 12 volt + power exits the relay at pin# 87 and goes to the speed controller. Note: this relay is only installed on AC drive system vehicles. The connector is present on DC drive vehicle models as well.

The turn signal/hazards switch is powered from fuse location F2. Power is present at this fuse when ever the main battery disconnect is turned on. Power runs from fuse F2 to the turn signal flasher. Power exits the flasher and enters the steering column at pin# L & K. When the turn signal switch is turned on to the left power exits the steering column at pin# M and goes to the left rear tail light. Power also exits the steering column at pin# H and goes to pin# B of the front left turn signal. When the turn signal switch is turned on to the right power exits the steering column at pin# N and goes to the right rear tail light. Power also exits the steering column at pin# J and goes to pin# B of the front right turn signal. When the hazard signal switch is turned on power exits the steering column at pin# H, J, M, N & P feeding both front turn lights & both rear tail lights.

Park brake/Forward/Reverse Switch/Backup/Alarm/light

When the ignition key is turned on the controller powers up and sends 12 volt power to the common side of the parking brake switch. When the park brake is set the park brake switch is a NO/NC switch so on its NC side it outputs this 12 volts to pin# 8 of the digital dash display. As a result the park brake light displays on the digital dash display. When the park brake is released the park brake switch sends power out is NO side to pin# 2 of the forward/reverse switch. When the vehicle directional switch is placed in the forward direction power is feed out pin# 3 to the speed controller. When the vehicle directional switch is placed in the reverse direction power is feed out pin# 1 to the speed controller. The directional switch also turns on the backup alarm and light. Power for this is supplied by the fuse F12. This is 12 volt positive power is supplied only when the ignition key is turned on. Note: The 12 volts from the controller are completely isolated from the 12 volts from the DC/DC converter. The power from fuse F12 enters the switch at pin# 5. When the directional switch is placed in the reverse direction power exits the switch at pin #4 and goes to the backup alarm and light. Negative 12 volts is supplied by pin# 4,5 & 6 of the DC/DC converter.

Accessory power outlet

The accessory power outlet is powered by 12 volt positive coming from fuse F13 and 12 volt negative coming from pin #'s 4, 5 & 6 of the DC/DC converter. The positive power is live only when the ignition key is turned on.

Horn

The horn is powered by 12 volt positive coming from fuse F12. The 12 volt positive power is live to the horn when ever the ignition key is turned on. 12 volt negative goes from pin# 4, 5 & 6 of the DC/DC converter. The ground runs to the horn button. When the button is pressed it closes the circuit and sends ground to the horn.

Head lights

The headlights are powered by fuse F11 which is only live when the ignition key is turned on. Power runs from F11 to pin# 2 of the low beam headlight switch. When the low beam headlight switch is turned on it closes the circuit and sends power out pin# 3 of the switch to the front low beam headlights pin# B, rear tail lights, license plate light pin #2 and the to pin# 2 of the high beam headlight switch. When the high beam headlight switch is turned on it closes the circuit and sends power out pin# 3 of the switch to the front high beam headlights pin #B. Ground for all these lights are from pin# 4, 5 & 6 of the DC/DC converter.

Single wiper arm window wiper motor

The wiper motor is powered by fuse F13 which is only live when the ignition key is turned on. Power runs from F13 to pin# 3 of the window wiper motor. Ground is supplied from pin# 4, 5 & 6 of the DC/DC converter to pin# 2 of the wiper switch and pin #2 of the wiper motor. When the switch is turned on the circuit is closed and sends ground out pin #3 to pin# 1 of the wiper motor.

Dual wiper arm window wiper motor/Washer pump

The wiper motor is powered by fuse F13 which is only live when the ignition key is turned on. Power runs from F13 to pin# P of the wiper motor and pin# 2 on the wiper switch. Power also runs to pin# 5 of the wiper switch if the vehicle is equipped with a window wiper washer pump. When the wiper switch is turned on the switch closes the circuit and sends power out of pin# 3 to pin# L of the wiper motor. Ground is supplied to the wiper motor at pin# S from pin# 4, 5 & 6 of the DC/DC converter. If the vehicle is equipped with window washer pump the wiper switch will have a third momentary position. When the switch is turned on to this momentary position the switch continues to feed power out pin# 3 to the wiper motor but also sends power out pin# 6 that runs to the window wiper washer pump. The washer pump is grounded from pin# 4, 5 & 6 of the DC/DC converter.

Radio/Speakers

The radio is powered by the fuse in F3 location. F3 fuse is live when ever the main battery disconnect is turned on. Positive 12 volts runs from the F3 fuse location to pin# 9 of the center console connector to pin# 2 of the radio connector. The radio has a 10 amp fuse attached to the rear of it as well. Negative is supplied from pin# 4, 5 & 6 of the DC/DC converter. The radio ignition power is supplied by fuse F14 which is live only when the key is on. Power runs from fuse F14 to Pin# 7 of the center console connecter to Pin# 3 of the radio connector. When power is present at pin# 1, 2 & 3 of the radio and the power button is pressed on the radio it should turn on.

12 volt Acc. Battery (AC Drive Only)

The 12 volt accessory battery is a power reservoir for when the DC/DC converter can not produce 12 volts anymore. This happens when the pack voltage drops below 57 volts. On AC drive systems this can happen during normal driving so this battery needs to be installed. The positive side of this battery is wired directly to fuse location F5. The Negative side of the battery is wired to pin# 4, 5 & 6 of the DC/DC converter. The DC/DC converter charges this battery when ever the main battery disconnect is turned on. Before you load test this battery the F5 fuse must be removed. Note: Both the main battery disconnect must be turned off and the fuse in F5 must be removed to disconnect the 12 volt power supply from the vehicle.

DC Drive Controller

Ignition& interlocks

The DC drive controller powers up when positive pack voltage is present at pin# 1 and negative pack voltage is present at terminal B-. The positive pack voltage comes from the ignition relay. The negative pack voltage comes from the main battery disconnect. When the main battery disconnect and the ignition key are turned on, pack voltage should be present at pin# 1 & terminal B-. Positive pack voltage will also be present at pin# 2. Which is an unused interlock input. When the controller powers up it will first check itself for any internal errors. If no errors are present it will send out a resisted pack voltage ground out pin# 17 for a split second that will close the main contactor. If the correct amount of pack voltage is present it will continue to hold the contactor closed and reduce its ground to 18-24 volts. If errors become present because either the contactor did not close or the voltage dropped below 50 volts it will stop trying to close the contactor an then show an error code with the led lights on the controller. See error code. If no error codes are present then it will supply +12 volts out pin# 4 and ground out pin# 2 of the four pin connector on the controller. This will supply power to all the driver inputs of the controller. See below.

Direction Selection

+12 volts is supplied by pin#4 of the 4 pin connector to the forward/reverse switch. When the directional switch is placed in the forward direction +12 volts is supplied into pin# 10 of the controller. When the directional switch is placed in the reverse direction +12 volts is supplied into pin# 11 & 3 of the controller. Pin#3 is to place the controller into a different drive mode so the vehicle will accelerate and a different rate and will only achieve about 10 MPH.

Accel Pedal (Vehicle built date before 12/23/08)

+12 volts is supplied by pin#4 of the 4 pin connector of the controller to pin# F of the accel pedal. When the accel pedal is pressed a safety switch inside the pedal closes sending power out pin# D of the accel pedal to pin# 8 of the controller telling the controller the accel pedal has been pressed and know can respond to the potentiometer voltage input. The safety switch is an interlock so if the switch does not close the vehicle will not move. The accel pedal sends out a variable voltage of 0-5 volts into pin# 15 of the controller. See accel pedal order of operations for more understanding. 0 volts means 0% throttle. 5 volts means 100% throttle. Programming inside the controller has been altered to match the accel pedal installed in your vehicle. This voltage is typically .8-3.8 volts.

Accel Pedal (Vehicle built date after 12/22/08)

+12 volts is supplied by pin#4 of the 4 pin connector of the controller to pin# E of the accel pedal. When the accel pedal is pressed a safety switch inside the pedal closes sending power out pin# D of the accel pedal to pin# 8 of the controller telling the controller the accel pedal has been pressed and know can respond to the potentiometer voltage input. The safety switch is an interlock so if the switch does not close the vehicle will not move. The accel pedal sends out a variable voltage of 0-5 volts into pin# 15 of the controller. See accel pedal order of operations for more understanding. 0 volts means 0% throttle. 5 volts means 100% throttle. Programming inside the controller has been altered to match the accel pedal installed in your vehicle. This voltage is typically .2-4 volts.

Main Contactor

The main contactor is nothing but a large relay. The two large post are the contact side and the two small posts are the coiling side. The coiling side is setup for 24 volts. When the ignition key is turned on positive pack voltage is ran from the ignition relay to one of the small post of the main contactor. At the same time the speed controller powers up and if it senses that there are no issues with the drive system it closes the contactor by supplying a resisted ground from pin# 17 of the controller to the other small post of the main contactor. This is why the contactor is setup for coiling of 24 volts. The controller actually closes the contactor with pack voltage for a split second and then drops the voltage to 18-24 volts.

Error Codes

See service manual.

Programmer connector

Inside the cab of the vehicle above the accel pedal and next to the connector that plugs into the center console there is a small four pin square female connector that is not plugged into anything. This connect is for a hand held diagnosis tool to plug into. The diagnosis tool is made by Curtis Instruments and has a model# of 1311. +12 volts is supplied by pin#4 of the 4 pin connector of the controller to pin# 4 of this connector. Negative is supplied from pin# 2 of the 4 pin connector of the controller to pin# 2 of this connector. The two communication wires are pin# 1 & 3 of both the connectors. The four pin connector in the cab is just an extension from the four pin connecter on the controller. In order for the programmer to start up it needs to be plugged into this connector and the ignition key needs to be turned on.

AC Drive Controller

Ignition& interlocks

The AC drive controller powers up when positive pack voltage is present at pin# 1 and negative pack voltage is present at terminal B-. The positive pack voltage comes from the ignition relay. The negative pack voltage comes from the main battery disconnect. When the main battery disconnect and the ignition key are turned on, pack voltage should be present at pin# 1 & terminal B-. When the controller powers up it will first check itself for any internal errors. If no errors are present it will send out a resisted pack voltage ground out pin# 6 for a split second that will close the main contactor. If the correct amount of pack voltage is present it will continue to hold the contactor closed and reduce its ground to 18-24 volts. If errors become present because either the contactor did not close or the voltage dropped below 50 volts it will stop trying to close the contactor an then show an error code with the led lights on the controller. See error code. If no error codes are present then it will supply +12 volts out pin# 25 and ground out pin# 7 of the four pin connector on the controller. This will supply power to all the driver inputs of the controller. See below.

Direction Selection

+12 volts is supplied by pin#25 of the controller to the forward/reverse switch. When the directional switch is placed in the forward direction +12 volts is supplied into pin# 22 of the controller. When the directional switch is placed in the reverse direction +12 volts is supplied into pin# 33 of the controller.

Accel Pedal (Vehicle built date before 12/23/08)

+12 volts is supplied by pin#25 to pin# F of the accel pedal. When the accel pedal is pressed a safety switch inside the pedal closes sending power out pin# D of the accel pedal to pin# 9 of the controller telling the controller the accel pedal has been pressed and know can respond to the potentiometer voltage input. The safety switch is an interlock so if the switch does not close the vehicle will not move. The accel pedal sends out a variable voltage of 0-5 volts into pin# 16 of the controller. See accel pedal order of operations for more understanding. 0 volts means 0% throttle. 5 volts means 100% throttle. Programming inside the controller has been altered to match the accel pedal installed in your vehicle. This voltage is typically .8-3.8 volts.

Accel Pedal (Vehicle built date after 12/22/08)

+12 volts is supplied by pin#25 of the controller to pin# E of the accel pedal. When the accel pedal is pressed a safety switch inside the pedal closes sending power out pin# D of the accel pedal to pin# 9 of the controller telling the controller the accel pedal has been pressed and know can respond to the potentiometer voltage input. The safety switch is an interlock so if the switch does not close the vehicle will not move. The accel pedal sends out a variable voltage of 0-5 volts into pin# 16 of the controller. See accel pedal order of operations for more understanding. 0 volts means 0% throttle. 5 volts means 100% throttle. Programming inside the controller has been altered to match the accel pedal installed in your vehicle. This voltage is typically .2-4 volts.

Main Contactor

The main contactor is nothing but a large relay. The two large post are the contact side and the two small posts are the coiling side. The coiling side is setup for 24 volts. When the ignition key is turned on positive pack voltage is ran from the ignition relay to one of the small post of the main contactor. At the same time the speed controller powers up and if it senses that there are no issues with the drive system it closes the contactor by supplying a resisted ground from pin# 17 of the controller to the other small post of the main contactor. This is why the contactor is setup for coiling of 24 volts. The controller actually closes the contactor with pack voltage for a split second and then drops the voltage to 18-24 volts.

Error Codes

See service manual.

Programmer connector

Inside the cab of the vehicle above the accel pedal and next to the connector that plugs into the center console there is a small four pin square female connector that is not plugged into anything. This connect is for a hand held diagnosis tool to plug into. The diagnosis tool is made by Curtis Instruments and has a model# of 1311. +12 volts is supplied by pin#25 of the controller to pin# 4 of this connector. Negative is supplied from pin# 7 of the controller to pin# 2 of this connector. The two communication wires are pin# 1 & 3 of the four pin connector in the cab. Pin# 1 comes from pin# 29 of the controller and pin# 3 comes from pin# 28 of the controller. In order for the programmer to start up it needs to be plugged into this connector and the ignition key needs to be turned on.

Motor Encoder

The motor encoder is a speed sensor mounted to the rear of the motor. +5 volts is supplied to the encoder from pin# 26 of the controller through pin#1 of the motor connector. Ground is supplied from pin# 7 of the controller through pin# 2 of the motor connector. The encoder consist of a reader head and a position disk. The position disk is a metal disk that has 64 square holes in it. The reader head reads each of the square holes. Each time it goes through a hole it sends out a so called phase A signal through pin# 3 of the motor connector to pin# 31 of the controller. Each time no hole is present the reader head sends out a so called phase B signal through pin# 4 of the motor connector to pin# 33 of the controller. The phase A signal is also sent to pin# 5 of the digital dash display.

For a more in-depth view in how the AC controller works read below.

The AC drive controller converts DC battery power to 3-phase AC power by precisely controlling the induction drive for high bandwidth, high efficiency, and low ripple torque generation. To realize this level of precise torque control of induction motor drives in electric vehicles, Curtis engineers carefully evaluated and incorporated the latest technology in microprocessors, power electronics, and motor control. Invented by Nikola Tesla in 1888, the induction motor became a workhorse that contributed to the vast industrial growth in the twentieth century. Until recently relegated to non-dynamic applications where transient response wasn't a critical concern, induction motors are now the motor of choice in high performance control applications. This shift was facilitated by the enormous advancements in microprocessors and power silicon devices in the last twenty years, coupled with intense research and development. The 3-phase induction motor has three sets of distributed windings in the stator winding slots. The standard induction motor has a rotor with aluminum bars short-circuited by cast aluminum end-rings. There are no brushes, commutators, or slip-rings, and—unlike DC and synchronous motors—there is no need for permanent magnets or a separate current supply for the rotor. The brushless construction of the induction motor and the rugged rotor provide high reliability, fault tolerance, low maintenance, and low cost. Three-phase sinusoidal voltages, electrically displaced by 120°, are applied to the phase windings to create the stator magnetic field. The field rotates at the stator voltage frequency times the number of pole pairs. This rotating stator field induces currents in the conductive rotor bars by transformer action which, in turn, create a second rotor magnetic field. The rotor field reacts to the stator field to generate torque. The differential speed, or slip frequency, between the stator field and rotor speed is critical to the torque and speed control of an induction motor.

Motor Control Algorithms

Two main approaches are commonly used for induction motor control: scalar control and vector control.

Scalar control (e.g., volts/Hz) modulates only the magnitude and frequency of the applied voltage or current. Although scalar control has the advantage of being simpler than vector control, it has poor dynamic response and lower operation efficiency. The various methods used to improve performance require extensive characterization of the motor and loads.

Vector control (e.g., indirect rotor flux orientation, stator flux orientation, etc.) manipulates the magnitude, frequency, and phase of the control variables to provide better control. The mathematical model of an induction motor is complex. Using a series of reference frame transformations, vector control simplifies the model to enable precise control of torque and flux, similar to a SepEx motor controller.

Figure A-1 shows a typical diagram of indirect rotor flux orientation. The instantaneous 3-phase currents are transformed to the rotor flux reference frame, using rotor speed and slip frequency—which means that the motor currents are now observed from the viewpoint of rotating with the rotor flux. As a result of this transformation the currents, now in what is called the d/q reference frame, lose their sinusoidal nature and look like DC signals. In the d/q reference frame, q-axis current controls torque and d-axis current controls flux. If properly oriented, the torque and flux remain independent of each other, and the motor can achieve high efficiency and dynamic response.

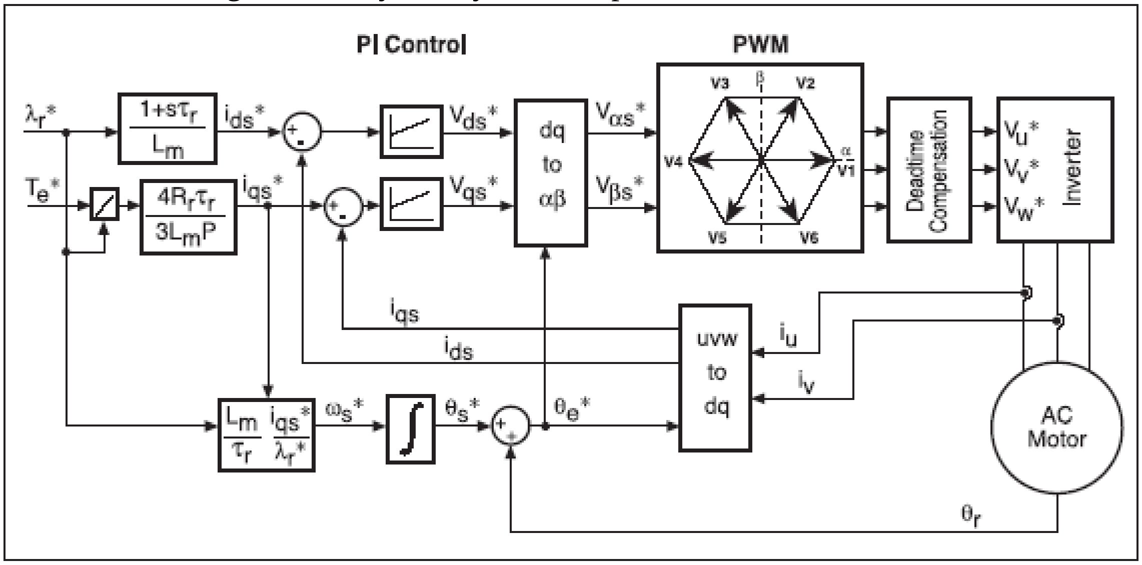


Fig. A-1 *Diagram of Indirect Field Orientation (IFO) technique.*

The controller uses an advanced pulse width modulation technique to maximize the utilization of battery voltage, minimize harmonic losses, and increase system efficiency. This method achieves 15% greater linear utilization of battery voltage, thereby effectively getting more usable motor power than standard PWM at the same battery voltage.

Power Section

The power section efficiently generates high current 3-phase AC signals from the DC battery voltage to drive the AC motor as requested by the motor control algorithms.

The power section is implemented as three high frequency MOSFET half-bridge power stages controlled by three pulse width modulators, as shown in Figure A-2. Each half-bridge power stage is a parallel array of high-side and low-side power MOSFETs mounted to Insulated Metal Substrate (IMS) circuit board. This technology provides a very low thermal resistance to the heatsink and enables high power capability in a compact area.

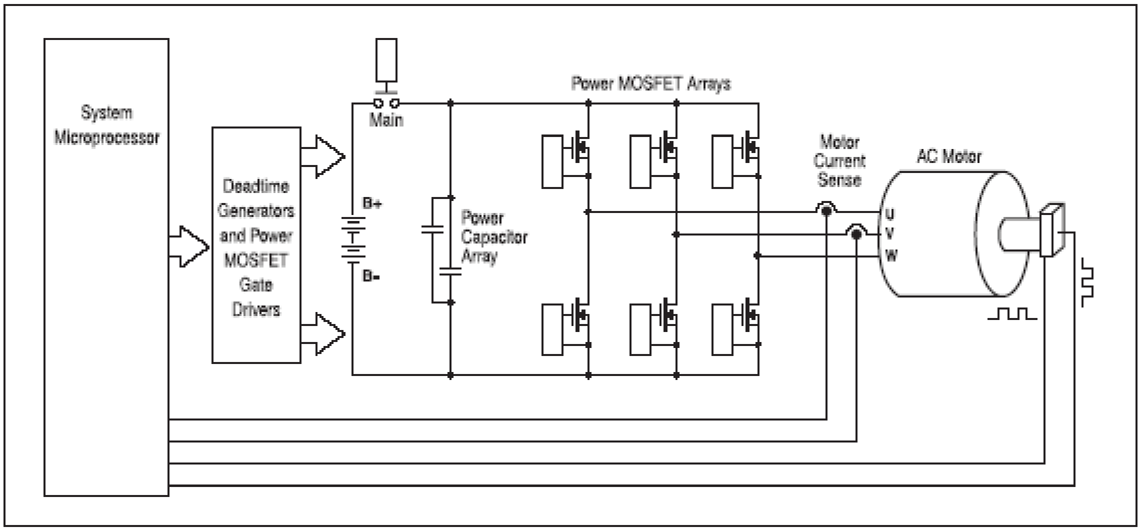


Fig. A-2 *Power section topology.*

Heavy copper busbars connect the IMS modules to the brass external motor connection studs. A bank of power capacitors keeps DC bus levels stable during high frequency MOSFET switching and also reduces EMI on the external B+ and B- cables.

Motor currents and motor speed and direction are the primary feedback signals used in the motor control algorithms. Accurate Hall sensors detect the motor currents; they do this by sensing the flux created by the motor currents on the U and V motor output busbars where they pass through the capacitor board on their way to the external motor connections. Motor speed and direction are simultaneously sensed by a quadrature-type speed encoder mounted on the motor shaft.

Chapter 5: Mechanical/Chassis Systems

5.1 Axle/Motor/Rear Suspension

5.1.1 Axle/Motor/Rear Suspension Disassembly

1. Begin by jacking the vehicle up in the rear on the axle housing.
2. Place jack stands so that they rest on the brace just ahead of the rear wheels that runs the full width of the car.
3. Disconnect the main battery disconnect located in the front right wheel well before doing any work on the vehicle's electrical system.
4. Remove the cable connections on the top side of the motor and make note of where each was located for ease of reassembly.
5. Remove the wheels, park brake cable pins from the brake actuator lever, and brake lines that connect the axle and chassis.
6. Place a jack under the axle housing and remove the nuts from the u-bolts. The axle and motor assembly will now be free to lower on the jack and remove from under the vehicle. Be careful once the axle u-bolts are free as the axle and motor assembly is very top heavy and will want to roll either forward or back.
7. Remove the motor from the axle housing. The motor is attached with bolts from the opposite side of the housing. Once these bolts are removed the motor might still need to be lightly pried from the housing. Be careful when removing the motor from the housing because it is very heavy. Note: If the motor is needed to be removed individually, special precautions should be taken to prevent personal injury due to the size and weight of the motor and space available to remove it.
8. The leaf springs can then be removed. Note: If the leaf springs are the only thing needed to be disassembled, they can be done one at a time with the axle still in the vehicle. With the vehicle still on jack stands, place a jack under the brake assembly and lift the axle to remove the weight of the axle from the spring, then remove the mating components from the spring.

5.1.2 Axle/Motor/Rear Suspension Assembly

1. Install the leaf springs, axle assembly, and motor in the reverse order from disassembly.
2. When re-installing the leaf springs, be sure to tighten the rear suspension pivoting bolts only snug enough to eliminate play, but still allow un-bound rotational motion. This is approximately 10-15 ft-lbs of torque with a new lock nut.
3. Re-torque the axle bolts to 40 ft-lbs.
4. Make sure that there is a small amount of grease on the axle input shaft. If there is none present, add a little bit to the splines before installing the motor. Re-torque the motor bolts to 10 ft-lbs.
5. Re-install the cables to the motor as they were assembled (see section 4.3 AC or DC cabling sections if needed).
6. Re-torque the wheel lug nuts 100 ft-lbs in an alternating criss-cross pattern.
7. Bleed the air from the rear brakes before attempting to drive the vehicle.

5.2 Front Suspension and Steering

5.2.1 Front Brake, Hub, Suspension Disassembly

1. Begin by jacking the vehicle up in the front placing the jack under the front horizontal suspension plate.
2. Place jack stands so that they rest on the brace just behind the front wheels that runs the full width of the car.
3. Remove the wheel.
4. Remove the caliper from its mount on the steering knuckle. It is attached using 4 metric bolts that are visible from behind the rotor. This will allow you to remove the rotor from the hub.
5. The brake pads can then be removed from the caliper. They might need to be lightly pried from the caliper body to be removed.
6. Remove the hub dust cap by gently prying it from the hub. The cotter pin will need to be removed which will allow the removal of the castle nut along with the spacer washer, outer wheel bearing and hub.
7. The back side of the hub houses the inner wheel bearing. The bearing seal is pressed into the back of the hub and needs to be removed to get the inner wheel bearing out. A puller should be used to properly remove the seal without damaging it.
8. Next, the nuts need to be removed from the ball joint tapered studs accessible from the back side of the steering knuckle. Some type of ball joint separating tool will need to be used to break the taper. A pickle fork works well for this. For the upper ball joint, place the pickle fork between the top side of the steering knuckle and the upper control arm and drive it apart. For the lower ball joint, catch the fork between the taper of the ball joint above the boot and the bottom side of the steering knuckle and drive it apart. The boot may have to be pushed down to get the fork on the ball joint stud. Take care not to damage the ball joint boots when driving the pickle fork. If the boot is torn, it will need to be replaced before re-assembly.
9. Finish the removal of the steering knuckle by removing the bolt between the steering knuckle and the tie rod end. If the caliper mount bracket is removed from the steering knuckle for any reason, pay close attention to what (if any) shim is between them. This shim needs to be matched to the rotor on the vehicle.
10. The upper ball joint can be removed by unbolting it from the control arm, but the lower ball joint is pressed into the control arm and will need to be re-pressed if it is removed.
11. The upper and lower control arms can be removed by taking out the two bolts that hold each to the chassis mounts. The steel pivot sleeves and bushings can then be removed. The bushings are pressed into the control arm and will have to be replaced if they are removed.

5.2.2 Front Brake, Hub, Suspension Assembly

1. Re-assemble the front suspension, hub and brake assembly in the reverse order that it was disassembled.

2. Torque the control arm mounting bolts, shock mount bolts and the tie rod mounting bolt to 30 ft-lbs. (**Note that there are two different types of control arm pivot joints depending on the date the vehicle was produced. If the joint uses only the mounting bolt to pivot on and does not have a steel sleeve, then the mount bolts need to be tightened to 135 in-lbs instead.)
3. Install the steering knuckle to the ball joint studs by setting the steering knuckle onto the lower ball joint stud and pressing down on the joint while the nut on the stud is tightened. This will help set the taper fit between the two and keep the stud from spinning while the nut is being tightened. Use a similar procedure with the upper ball joint stud, but press the upper joint into the steering knuckle.
4. When installing the bearings back into the hub, be sure to fully grease the bearings themselves, the bearing races and the spindle shaft.
5. Slowly spin the hub on the spindle while tightening the spindle nut to 50 ft-lbs. Once the finish torque is reached stop turning the hub. Loosen the spindle nut <u>without</u> turning the hub. Torque the spindle nut to **25 <u>in</u>-lbs**. (Note: torque spec is in **Inch pounds** not foot pounds). If the hole in the spindle lines up with a castellation in the nut, then install the cotter pin and bend the ends apart. If the hole does not line up continue to torque the nut until the hole lines up with the next castellation – <u>Spindle nut torque should not exceed **45 in-lbs**</u>. (Note: torque spec is in **Inch pounds** not foot pounds). Then insert the cotter pin and bend the ends apart. (**Note that this process is only applicable to models that contain the 12-slotted castle nut).
6. Before the rotor and caliper are installed check to make sure that the correct shim is in place between the steering knuckle and the caliper mount. If a rotor is being replaced make sure that the new rotor and the shim are matched by contacting the service department at e-ride Industries. (**Note also that certain models contain no caliper mount shim. Pay attention to what was there from the factory)
7. If the brake pads have been removed, make sure that they are in the appropriate spot in the caliper so they are properly contained by the caliper. Improper placement can lead to rotor damage.
8. Re-torque the wheel lug nuts 100 ft-lbs in an alternating criss-cross pattern.
9. If the brake lines were removed during the disassembly, make sure to bleed the air from the front brakes before attempting to drive the vehicle.
10. If any components were replaced or the upper ball joint moved for any reason the vehicle will need to be aligned. Failure to do this could lead to rapid and/or uneven tire wear as well as improper handling characteristics. The specifications for alignment are given at the end of this section.

5.2.3 Steering System Disassembly

*The steering system can be disassembled either by removing the steering column first or the steering rack. This instruction will go through the process with removing the steering rack first.

1. Begin by removing the tie rod end bolts on each side and then the steering rack mounting bolts.

2. Remove the steering shaft lower universal joint. This can be accessed with the hood open by removing the top battery tunnel cover and then the screwed down fuse mount plate. To prevent shock danger when moving the fuse mount plate, turn off the main battery disconnect and remove the fuse from the F5 location before removing the mount screw for the plate. The tunnel cover is attached with Velcro, so remove it by simply pulling it up. Lay the fuse mount plate to the side and remove the bolts (metric) from the universal joint. The joint may have to be opened up to free it from the shafts. Insert a screwdriver in the slot and turn it to lightly pry the joint apart to free it so it slips out of the splined end.
3. The steering shaft can now be separated at the middle u-joint. Remove the bolt in the joint and use the same procedure as previously to remove the splined end.
4. The steering column can now be removed. The bolts can be accessed more easily by removing the dash and console. The console can be removed by first removing the center arm rest pad and then disconnecting the wiring harness plug. The console can then be slid back slightly and lifted up. The dash is then removed by taking out the screw on either end in the door jams. The steering column is then held in by four bolts. Remove the bolts and unplug the wiring harness and slide the steering shaft through the firewall when removing the column.
5. The steering wheel should be removed from the steering column if the steering shaft is disconnected from the steering rack for any reason. This helps in the centering of the rack and steering wheel after alignment of the vehicle. The steering wheel is removed by popping the center cap out of the steering wheel and loosening the nut. The wheel will require a puller to get it loose from the steering column.

5.2.4 Steering System Assembly

1. Re-assemble the steering system in the reverse order that it was disassembled, except be sure to install the steering wheel last so that the vehicle can be aligned and then the wheel can be oriented centered on the column again.
2. When installing the steering shafts in line between the column and rack make sure that orient adjacent steering shaft universal joints so that they are 90 degrees out of phase with each other. This will help to keep the steering movement free moving at all times.
3. When installing the tie rod ends torque the bolts to 30 ft-lbs.
4. It is best to align the vehicle any time the steering system is disassembled or if any components in the system were replaced for any reason. Failure to do this could lead to rapid and/or uneven tire wear as well as improper handling characteristics. The specifications for alignment are given at the end of this section.
5. The steering wheel will also need to be centered to the vehicle alignment. Once the wheel has been set in place, torque the nut to 50 ft-lbs.

e-ride Vehicle Alignment Specifications

Front				
Left		Measure	Right	
Low	High	Range	Low	High
-0.3	0.3	Camber (deg.)	-0.3	0.3
-0.031	0.031	Toe (in.)	-0.031	0.031
8.5	10.5	SAI (deg.)	8.5	10.5
8.2	10.8	Included Angle (deg.)	8.2	10.8

Rear				
Left		Measure	Right	
Low	High	Range	Low	High
-0.5	0.3	Camber (deg.)	-0.5	0.3
-0.2	0.2	Toe (in.)	-0.2	0.2

Totals		
Measure	Low	High
Cross Camber (deg.)	-0.3	0.3
Front Total Toe (in.)	-0.031	0.031
Rear Total Toe (in.)	-0.2	0.2
Thrust Angle (deg.)	-0.4	0.4

Table 10: Alignment Specifications

5.3 Doors

5.3.1 Door Disassembly

The door disassembly of the interior components and panel is something that can be done to a certain extent on the vehicle, but for the purpose of the entire disassembly the instruction will say to remove the door.

1. Begin by removing the door with the hinges from the vehicle which is attached to the body at the front exposed hinges with four bolts. Make sure the door is free from the latch and when the hinge bolts are removed the door will be loose. Take care in removing the door assembly because it will have some significant weight.
2. Lay the door interior side up on a flat table with a covered face so that the exterior surface of the door will not be scratched or damaged.
3. Remove the interior component screws to remove the interior door handle escutcheon, window crank, and recessed pull handle.

4. Remove the six interior molded panel screws and take off the interior door panel.
5. Remove the door hinges and the cage nut plates. When removing the hinges, make special note if there are any shims between the hinge and the door. These will need to be assembled in the same configuration for the door to fit properly. Then remove the latch cables on the rotary door latch actuator. The interior handle and rotary latch can also be removed at this point.
6. Remove the five screws that hold the outer panel tabs to the frame. They can be found along the front and back edges of the steel door frame. Once the frame is removed, the exterior door handle can be removed from the outer door panel as well.
7. Remove the bolts that hold the window raise channel (bonded to the glass) from the regulator actuator tab and the glass can be slid out the bottom of the frame. Handle the glass with care because the corners or edges may be sharp.
8. If the glass is broken or for some reason needs to be replaced the bonded bracket needs to be removed from the glass. Remove the screws holding the bracket halves together and pry the bracket apart and away from the glass. Make sure to remove any left-over glue or glass particles from glass bonding surface. If the glass bracket is damaged or bent in any way it should be replaced. The slightest bend or damage can cause the bracket to destroy the new glass.
9. At this point the regulator can be removed from the frame by taking out the four screws that secure it. Un-hook the regulator tail from the hook on the frame and feed it through the opening in the frame as the regulator is removed.

5.3.2 Door Assembly

1. Re-assemble the door in the reverse order that it was disassembled.
2. Apply thread locking compound to the regulator mount screws.

3. Use rubber glass seal strip tape part# U2824A-N to bond the glass bracket to the glass. Make sure the bracket is centered on the glass so there is no tension on the regulator guide when the bracket is bolted to the regulator.
4. Now slide the regulator tail bracket part# U2371A-N onto the regulator tail. Use fiberglass two part epoxy to glue the regulator tail bracket to the inner side of the outer fiberglass panel. Make sure regulator tail is straight up and down and the window rolls up and down smooth before the glue dries.
5. Install the interior handle and rotary latch to the door frame and the exterior handle to the outer door panel.
6. Install the frame to the outer door panel and attach both the inner and outer door cables to the back side of the rotary latch actuator in the order they were assembled (with the inner cable closest to the actuator and oriented so that the barrel of the cable eyelets are toward the outer door panel). Apply thread locking compound to the eyelet attachment screw
7. Check the rotary latch actuation from the interior and exterior handles. The rotary should open at the point where the interior handle is about 2/3 through its travel. Any adjustment should be made by removing the cable attachment

on one end and turning the brass nut on the handle. Typically, the correct adjustment for the interior handle is obtained with the eyelet threaded all the way into the brass nut and about 1" between the nut and the latch body. If the latch requires severe adjustment from this point, check the mating parts for defects. The exterior latch should open the rotary at about 7/8 of its travel. There is no adjustment in the exterior handle cable, so if it does not actuate correctly something is assembled wrong or a part is bad in some way.

8. Install the door hinges with the cage nut plates on the back side of each and the mirror mount block on the top hinge.
9. The interior door panel can now be installed followed by all the interior components as they were removed.
10. Install the door on the vehicle by bolting the hinges to the body thread inserts. The door adjustment will be made by loosening the hinge bolts on the door side just enough to allow movement of the hinge. If these bolts are loosened too much, they will fall off the cage nut plates inside the door and the interior panel will have to be removed to reassemble it. Adjust the door with even gaps all the way around and then re-adjust the door striker pin so that the door latch does not hang up on it through the door's swinging motion. Once the door is latched make sure that the interior surface of the door mates firmly to the bulb seal to prevent any leaks. Any adjustments can be made through a series of shims that can be placed between the door and the hinge. If the door requires extensive shimming apart from what was already there, inspect the mating components for defects.

5.4 Hydraulic Brakes

5.4.1 Front Brake Disassembly

The front brake disassembly, including pad removal, is covered in 5.2.1 and 5.2.2.

5.4.2 Rear Brakes – Dana Axle Disassembly

1. Jack the rear of the vehicle by lifting on the axle and secure with jack stands and remove the rear wheel.
2. Remove the push nut (retainer clip) on the outside of the drum and remove the drum by sliding it over the lug studs. The drum retainer clip will probably need to be destroyed to remove it and it is not needed for reassembly.
3. Using a right angle snap ring pliers remove the snap ring retaining the axle (and bearing) into the housing tube. Remove the axle shaft and bearing by pulling straight out.
4. Remove the compression springs by compressing the spring collar and turning it 90 degrees so it will slip off the hook. Remove the hook end tension springs from the shoes and remove the shoes

5.4.3 Rear Brakes – Dana Axle Assembly

1. Reassemble the brake and axle in the reverse order that it was assembled.
2. Make sure that the compression spring collar seats properly in the pin before moving on.

3. Make sure that the snap ring into the axle housing is fully in its groove before moving on. This is very critical since it is the only thing holding the axle in the housing.

5.4.4 Rear Brakes – Team Axle Disassembly

1. Jack the rear of the vehicle by lifting on the axle and secure with jack stands and remove the rear wheel.
2. Remove the pin and nut from the axle shaft and then remove the drum. The drum may require a puller to break loose from the shaft.
3. Remove the pins in the top of the brake shoes which hold the parking brake lever.
4. Remove the torsion springs on each pad by prying the straight end over the retaining tab and slide the brake pads out of the brake assembly.
5. Remove the spring and adjuster between the springs paying close attention to the orientation of the adjuster.

5.4.5 Rear Brakes – Team Axle Assembly

1. Reassemble the brake and axle in the reverse order that it was assembled.
2. Make sure that the adjuster is put back in the same orientation that it came out (the adjuster sprocket to the front).
3. Once the brake has been fully assembled and the wheel installed, adjust the adjuster sprocket with a screwdriver from the hole in the backing plate so that there is a light drag on the drum while the brake is not actuated, but the wheel can still spin freely

5.5 Parking Brake

There were two different styles of park brake that have been used by e-ride industries depending on what model vehicle and what the production date. The first is a ratcheting handle type that is located on the top of the battery tunnel and can be found in the most recent vehicles built. The second is over-center handle type located in front of the driver near the brake pedal. The over-center type was used in all e-ride models until the beginning of 2009 when the ratcheting handle was put into the EXV2 model. The EXV4 would follow suit by about May of that same year.

5.5.1 Ratcheting Handle Parking Brake Disassembly

1. Begin with park brake handle which can be accessed from inside the vehicle by removing the center arm rest pad and console. The park brake lever will have to be in the engaged position so that the handle is raised in order to remove the center pad (and tunnel cover once the console is removed later). Disconnect the wiring harness plug from the console. Then the console can be slid back slightly, lifted up and removed. The center aluminum tunnel cover, which is attached by Velcro, can then be lifted off. The park brake may have

to be engaged so that the handle is raised and the cover can be removed more easily.

2. The park brake can now be removed with the two bolts accessible from the inside of the battery tunnel and two on the outside and under behind the seat. These outside bolts are easily accessible in the EXV4 from the rear seat, or in the EXV2 through the driver's side outside storage compartment door. Take caution not to contact any metal objects to the battery terminals when working inside the tunnel. **Disconnecting the battery disconnect switch does not kill power from a battery post or the cables between the batteries**.
3. Disconnect the park brake switch plug and then remove the cable e-clip, pin and clip to free the cable from the handle assembly. *Note that the pin is installed from the battery side of the handle with the clip side away from the batteries and will need to be reassembled in this direction only.
4. The rest of the system is located under the vehicle and each component can be accessed individually without any further disassembly and in any order. Remove cable e-clips, clips and pins to free up any desired cable.

5.5.2 Ratcheting Handle Park Brake Assembly

1. Reassemble the park brake handle in the reverse order that it was disassembled. **Make sure that pin holding the cable to the park brake handle lever is installed from the battery side of the handle with the clip side away from the batteries. If this clip is installed the incorrect way, contact with the battery post may occur.**
2. The system will need to be adjusted to get the park brake to perform effectively. All adjustment is done underneath the vehicle at the equalizer junction. The nut in the equalizer can be accessed by removing the clips and pins from the cables in the equalizer and sliding the equalizer bracket forward on the threaded rod. This nut should be tightened so that the pins can just barely be put back in the equalizer by hand. This will ensure that the park brake has adequate holding power for the input lever force, but does not drag the brakes when released.

5.5.3 Over-Center Handle Park Brake Disassembly

1. Begin with park brake handle which can be accessed from inside the vehicle attached to the brake pedal mount.
2. The park brake handle can be removed by the two mount bolts along with the switch and bracket.
3. Disconnect the park brake cable by removing the pin and bushing. The cable can then be removed by taking off the e-clips on either end.
4. The rest of the system is located under the vehicle and each component can be accessed individually without any further disassembly and in any order. Remove cable e-clips, clips and pins to free up any desired cable, rod or return spring.

5.5.4 Over-Center Handle Park Brake Assembly

1. Reassemble the park brake handle in the reverse order that it was disassembled.
2. The system will need to be adjusted to get the park brake to perform effectively. There are two adjustment points for this system. The first is located underneath the vehicle at the equalizer junction. The nut in the equalizer can be accessed by removing the nut holding on the return spring bracket. There is an adjuster nut and a jam nut. The adjuster nut should be tightened so that the pins can just barely be put back in the equalizer by hand. This will ensure that the park brake has adequate holding power for the input lever force, but does not drag the brakes when released. The second adjustment point is the handle itself. Turn the end of the handle to tighten or loosen the pull tension.

5.6 Flatbed Removal for EXV2

The flatbed on the EXV2 can be removed for better access to the components in the rear of the vehicle and the batteries. This might make the inspection and troubleshooting process easier. The flatbed often supports one or more optional components attached to it; such as a full length or short enclosure, ladder rack, tool boxes, etc. These options can either be removed from the bed prior to disassembly or, if the correct equipment and/or manpower are available, the bed can be removed with everything mounted on it in most cases.

5.6.1 Flatbed Disassembly

1. There are four bolts at the rear of the flatbed that are a carriage style and mount to the rear bumper mount tubes. The bolts are exposed on the top of the flatbed and the nuts are accessible from underneath the vehicle. These nuts can be removed to free up the bed even if there is some type of optional component bolted over the top of the carriage head.
2. There are two large screws (one on either side) accessible in most cases from inside the cab slightly behind and to the outside of the seats along the bottom rail of the enclosure. There is a clearance hole in the enclosure and the screw is recessed inside the hole in the tube rail. Remove the Phillips pan head screw on either side to free the bed from the vehicle.
3. In cases where the vehicle utilizes some type of rear enclosure, there will be a clamp channel mounted to the top of the B-pillar above the occupants heads that hold the enclosure sealed to the B-pillar. These channels are held on with two screws each and will have to be removed to remove the enclosure (which could be left on the bed if desired, as discussed above) and in-turn, the bed.
4. Lift the bed off the chassis when removing it. Do not slide the bed on the chassis or the foam tape seal between the two will be torn and need to be replaced.

5.6.2 Flatbed Assembly

1. Install the bed by lining up the bolt holes for the removed bolts and replacing the bolts. Inspect the seal between the bed and the chassis to make sure it is not

damaged in any way that would compromise its usefulness and replace if necessary before installing the bed.

2. Make sure to take great care when reinstalling the rear enclosure of any type that the base and B-pillar seals are not disrupted or damaged in any way. These seals are critical to the leak prevention of the closed areas of the vehicle. Also check when reinstalling the clamp channels to the B-pillar that the enclosure makes a positive seal to the pillar. If the enclosure does not line up as it did when it was disassembled, check the alignment of the bed on the chassis for correctness.
3. The most important thing when reinstalling anything pertaining to the cab is to check for seal or other issues that could lead to water leaks into the cab or storage compartments.