

Advanced Troubleshooting Guide

Custom Equipment Lifts© 24V Battery Chargers

Rev 0 19SEP07

For 300W 24V charger:

1. How It Works: The Custom Equipment Lifts charger converts AC voltage to DC voltage with diodes (full wave rectifier), then uses high frequency to re-convert it to DC voltage/current to charge the battery. The charger automatically adjusts for the incoming AC voltage when first plugged-in. The AC voltage must fall within a “low AC voltage band” (85 to 130VAC) or “high AC voltage band” (170 to 264VAC) in order to operate. Connection to 330V or 480V three phase will fail the charger.

The charging curve consists of four parts:

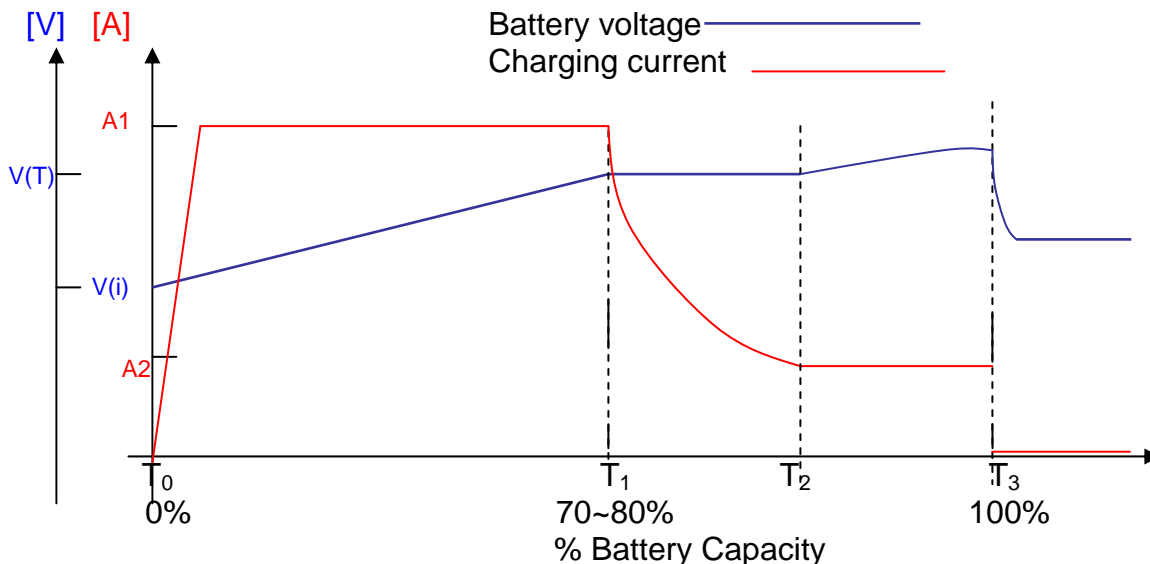
Constant current – charging current is held constant while battery voltage rises to a pre-set voltage level,

Constant voltage – battery voltage is held constant while charging current goes down,

Constant current – charging current is held constant while battery voltage rises, and

Maintenance – charger is off but monitors battery and maintains it in charged condition.

A graph of the charging current and battery voltage looks like this:



Constant current stage (bulk mode) – 0 to 70% battery charged - The charger smoothly increases the charging current (in Amps) to the value shown in **Table 1** below. The charger then holds this charging current fairly constant as the battery voltage rises and the battery charges. Note this is very different from older transformer chargers where charging current drops the whole time. In places where the AC voltage might be below 100VAC (Japan for example), the charging current may be slightly lower than **Table 1**, depending on the AC voltage and the battery condition. The battery voltage rises from $V(i)$, the battery voltage at the start of charging, to a pre-set value called $V(T)$ when the next charging stage starts.

Constant voltage stage (absorption mode) - 70% to 90% battery charged – The charger now adjusts the charging current downward to hold the battery voltage at the voltage setting V(T). When the current drops to the A2 setting in **Table 1** the next charging phase starts.

Constant current stage (dV/dt) – 90 to 100% battery charged – The charging current is held at the A2 (Amps) value in **Table 1**. The computer in the charger measures the rise of battery voltage or, in other words, how much the battery voltage is going up per hour.

Charging complete – When the battery voltage is going-up less than 0.1 Volts per hour the battery has taken all the charging it can take and charging stops. The charger then goes into maintenance mode.

Maintenance mode – if the charger is left plugged-in after charging is complete, it will go into maintenance mode. If the battery voltage falls below 25V during storage, the charger will turn on automatically and complete a (short) charge cycle to keep the battery at full charge. Note that this charger does not keep a continuous trickle charge that boils the water out of the battery so it can be safely left on (plugged into AC).

2. Troubleshooting

First, make sure the “Quick Guide”, found at the end of this document, is used. Advanced troubleshooting follows and assumes the reader is familiar with voltage, current, and how to use a DVM (Digital Volt Meter).

2a. No LEDs

The biggest reason for no LED's is no AC power to the outlet (or extension cord) that the charger is plugged into. Try a trouble light or other to make sure AC power is present. The next most likely cause is a bad AC cordset – that is the AC cord with the IEC connector (computer type connector) on one end and an AC plug on the other end. These cordsets can go bad, especially if the original Custom Equipment Lifts cord has been replaced by a lower power / lower quality computer cord. Try a different, known good cordset.

If there are no LEDs, and you are sure there is AC power going to the charger and the AC cord and plug are good, the charger is bad. If this has happened to more than one charger at one site then it is possible the AC voltage is failing the charger. Check to make sure the AC voltage is between 90 to 130VAC or 170 to 264VAC and that there are no large spike voltages. Spike voltages over 270V will fail the charger. Lightning strikes, if large enough, can also fail the charger and will usually fail other equipment on the same circuit. The charger does have protection for high voltage inside and meets all international standards for spike voltages, but a steady high voltage (for example, connecting to one leg of three-phase voltage) or a large spike can fail the charger.

The following applies only for chargers where the LED's light but you are concerned the charger may not be working correctly.

2b. One Flash

The charger will not operate if it is not connected to a battery. Some users have taken a replacement charger, put a voltmeter on the output, plugged it in, and then say it is bad because

they get a one flash and no voltage. The charger will not start charging unless it sees a battery voltage of at least 2V for an on-board charger, and 17V for an off-board charger (with handle), of the correct polarity, at the output (black and red wires).

One flash also occurs when:

- The charger output is connected in reverse polarity, that is the red wire of the charger is connected to battery minus (-) and the red wire to battery positive (+).
- There is an open circuit somewhere else in the battery circuit. For example, although the charger wires may be connected to the battery the wires (cables) **between** batteries may be disconnected or open.
- There is high resistance somewhere in the battery charging circuit. Even when a DVM (Digital Volt Meter) shows voltage at the wires going to the charger this could be the problem. DVMs have very high internal resistance so even if there is a poor connection the DVM will read normal voltage. The charging circuit however is a low resistance circuit so a poor connection (high resistance) prevents the charger from being able to develop full charging current and a one flash may occur. All connections should be removed, made clean and bright, and firmly reconnected.

2c. Two Flash

A two flash indicates that the AC incoming AC voltage from the wall outlet is outside the voltage bands where the charger will work. The voltage bands of 90 to 130 and 170 to 264 are the guaranteed AC operating voltage ranges. Many chargers will work on voltages above and below these voltages, however, damage can occur if run for long periods of time outside these voltages. The AC voltage can go above 130V for brief periods, less than 5 seconds, and the charger will not fault and go into “two flash” but will work normally. A two flash indicates the AC voltage is staying outside of the normal operating AC voltage band for longer than 5 seconds.

If you have measured the AC voltage and it is within the voltage band, and you have a two flash, replace the charger.

2d. Three Flash

The charger constantly senses the temperature inside the charger and protects itself by cutting-back charging if it gets too hot. The charger will recover automatically when it cools. This just indicates that the charger probably has its cooling fins clogged and needs to be cleaned.

There is no known failure mode where a three flash occurs but the charger is not overheated. There have been few reports of overheated chargers in general, however, keeping the cooling fins clean will keep the charger running cooler which will make it last longer.

2e. Concern that charger is working right (low output or other concern)

For advanced service people, a current shunt and voltmeter can be used to see what the charger is actually doing. Very few VOMs or DVMs can handle 11A in their current measuring circuit so a current shunt must be used. You may have a clamp-on ammeter, which can be used instead of a shunt, **but make sure the clamp-on ammeter reads DC current.** Most clamp-on ammeters only read AC current and register “0” for DC current. DC clamp-on ammeters are expensive so unless you already have one a current shunt may be lower cost.

An example of this shunt can be purchased from Jameco Electronics, www.jameco.com, part number 162309, for around \$35. The shunt suggested here is a 50mV per 50A shunt so every 1mV measured on the shunt equals 1A of charging current.

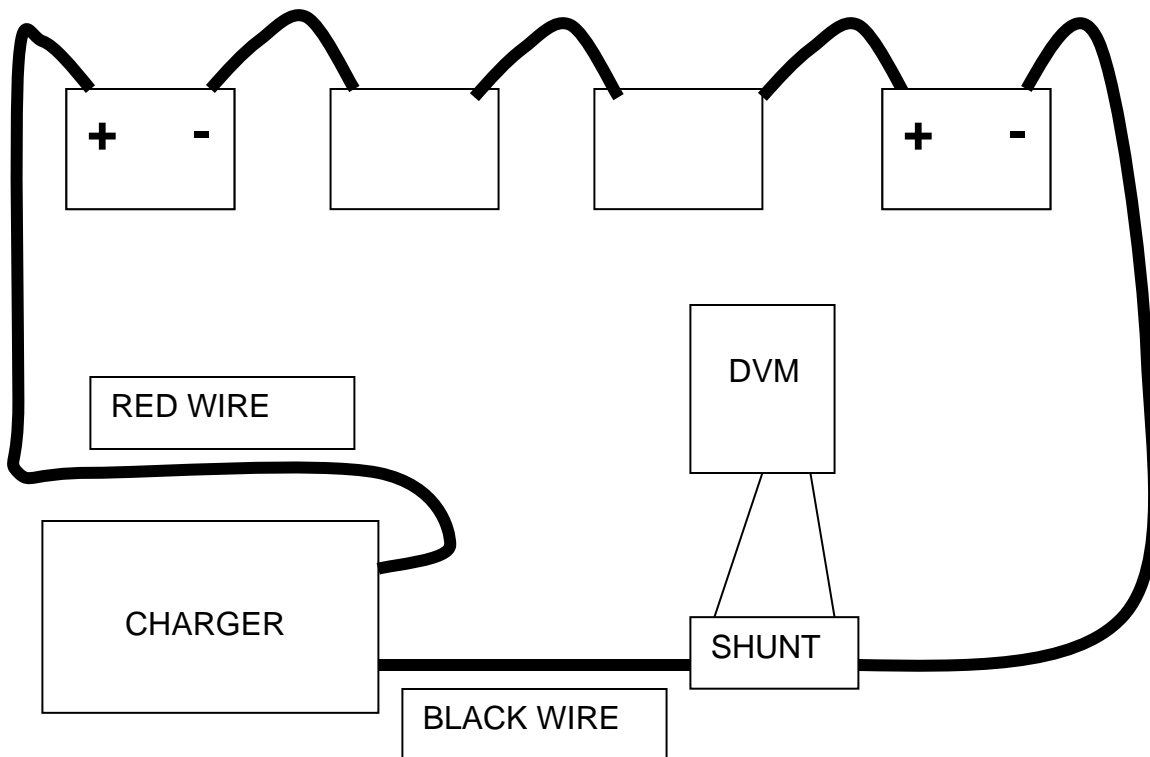
Connect the shunt in series with the charging circuit. It can be in either the negative or positive side, just be careful not to short the shunt to any battery parts as severe sparking and possible harm can occur.

WARNING – CONTACT BETWEEN THE SHUNT AND ANY BATTERY POST CAN RESULT IN INJURY.

ONLY CONNECT THE SHUNT WITH THE CHARGER UNPLUGGED.

Use the DVM (voltmeter) across the shunt to read the charging current.

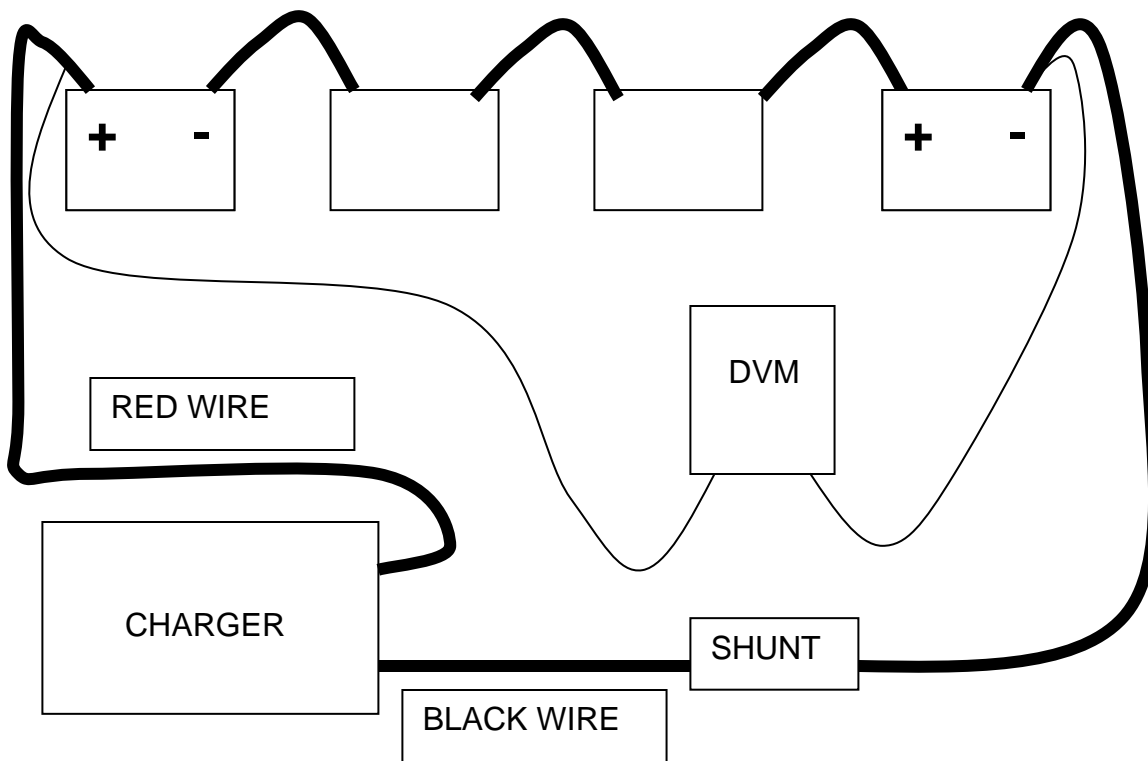
Note – Four 6V batteries shown here – some machines use two 12V batteries in series



Measuring Charging Current

Most DVMs have a millivolt scale or will automatically adjust to a millivolt scale. When in a millivolt scale the meter reading will correspond to the charging current in Amps (A) or $11\text{mV} = 1\text{A}$. Note that in the above drawing, the right terminal of the shunt would be positive, but polarity really is not a problem as you are looking for the charging current and your DVM will just show a negative reading.

Refer to the charging graph on page 1 and the table of charging values in **Table 1**. During the beginning of charging, the current readings should be the A1 values in **Table 1**. If the current is less than A1, then the battery voltage may already be high enough so that the charger is in the “constant voltage” stage of charging. You can check this by moving the voltmeter leads to measure battery voltage:



Measuring Charging (Battery Voltage)

Important – attach the voltmeter wires to the battery charger output terminals (red and black wires) so the voltmeter reads exactly the same voltage as the battery charger does.

If the battery voltage is above 28V (see section 2) then the charger is probably already in constant voltage mode charging and the charging current is dropping and the charger is OK.

All the charger can measure to determine how the battery is charging is battery voltage. It cannot measure specific gravity (SG). If the battery is bad, has high internal resistance, or resistance from bad or corroded cables, the battery voltage may read high despite the SG being low.

If the battery voltage has risen to 28V and you want to check the charger for full output, the easiest solution is to run the machine for a while, under heavy loading conditions, to get the batteries discharged enough so the charger goes into full constant current mode (A1 value) when plugged-in.

Charger engineer's note: Low charging output failures, that is, where the constant current charging is less than A1 values in **Table 1**, are rare. However, checking to make sure the charger is putting out full charging current helps to confirm the problem is somewhere else in the charger + battery system.

3. Charger completes charging, measurements look OK, but battery SG is low

The most common reason this occurs relates to a battery problem. Let us first look at new batteries as good chargers are sometimes returned with the comment "it must be the charger, the batteries are brand new or just replaced".

We have seen brand new batteries in the laboratory and in the field that do not charge correctly. New batteries must have a number of charge / discharge cycles before the plates "form" various chemical coatings. As the batteries "form" the capacity increases. It can take 30 to 40 charge / discharge cycles before plates fully form, but usually 6 or so charge / discharge cycles provide the majority of plate forming. During this plate forming time, the battery voltage may rise to levels that indicate a fully charged battery, yet the SG may be low. The customer may also complain about short running times. The solution is to use the machine normally and charge it normally.

If you are suspicious of the charger, you could take a machine that has just completed charging yet shows low battery SG, and run the machine under heavy load for 15 to 30 minutes. This will take enough energy out of the battery that your DVM should measure below 25V (battery voltage). Then plug the charger in and watch the voltage with your DVM; if it rises over 28V and the LEDs show charging progress the charger is working correctly and the battery just needs to be cycled (used).

Note – for maximum battery life avoid heavy discharge (below 21V open circuit) of new batteries. New batteries without formed plates are easily damaged by over-discharge. If you have a customer that has over-discharged brand new batteries, they may have ruined the batteries immediately resulting in short run times. Once a battery has "formed" plates it is much more durable and rugged.

If the SG reads low and the batteries are old, the batteries may have failed. As before, if you can confirm the charger is charging the battery voltage to above at least 27V it is unlikely the charger is the problem, the batteries are just not developing capacity despite the terminal voltage (V(T)) being correct. If the voltage never gets up to 27V and the charger is putting-out proper charging current, then one or more cells are bad and the whole battery pack needs to be replaced.

Charger Time-out - The charger will time-out and turn-off automatically if it is unable to charge the batteries correctly. A time-out can happen in two ways:

1) If the charger has been running for more than 18 hours and can not charge the batteries fully, it will turn-off and the error code will be the 50% and 75% LEDs "off" while the 100% LED blinks. Note from the graph on page one that this would be more than 18 hours from T0 to T3. In this case the batteries may be bad – see previous sections on batteries.

2) If the time from T1 to T3 exceeds 6 hours the charger shuts off automatically but no error code is flashed. In this case the batteries are not in good condition but have accepted as much charge as they are going to accept so the charger shuts off. For optimum machine run time the batteries should be replaced, but many customers may find the machine works fine even though the batteries are not in good condition.

Quick Guide to Troubleshooting Custom Equipment Lifts© 24V Charger –rev 0

LEDs light when plugged-in

1. The three green LED's labeled 50%, 75% and 100% flash together. pause, then flash again... (one flash)
 - Problem – bad connection from the charger to the batteries, or between the batteries (within battery pack), or reverse polarity (+ or red wire of charger to – of battery)
 - Solution – Check polarity - + to +, - to -. Take connection from charger to batteries and cables between each battery apart, clean to shiny, re-install. **Even when these connections look good they are often the problem.**
 - If still one flash then look for a cut or a short in the red and black wires going from the charger to the batteries
2. The green LED's flash two times, pause, flash two times ... (two flash)
 - Problem – bad AC voltage or bad charger
 - Solution – If charger is running off engine-gen set check AC voltage which must be between 85V to 130V or 170V to 274V, otherwise replace charger
3. The green LED's flash three times, pause, flash three times ... (three flash)
 - Problem – charger overheated (charger still works, just at reduced charging)
 - Solution – clean-off cooling fins, charger will work again automatically
4. The 50% and 75% LEDs are “off” and the 100% LED is flashing
 - The charger is unable to get the battery fully charged within 18 hours. This can occur with a deeply discharged or damaged (bad cell, sulfated, etc.) battery. You can restart a charge cycle by unplugging the AC power or the DC battery connection, waiting 30 seconds, then plugging back in again. Sometimes a deeply discharged or damaged battery can be “recovered” through use and charging.

No LED's when plugged-in

- A. No LED's
 - Problem – no AC voltage – inspect AC cord and AC plug for damage. Take replacement AC plugs apart to make sure the wiring is tight on screws and correct. A tag on the cord defines wiring.
 - Plug a light or something else into the same outlet as the charger just to make sure there is power to the charger.
- C. No LED's, power has been verified as getting to charger - Replace charger

Batteries do not charge overnight

- A. Make sure that power to the AC socket being used for charging is not being turned off at night when everyone leaves the building. This is common.
- B. Batteries are in poor condition. Check for bad cells or sulfation.
- C. New batteries with unformed plates. Brand new batteries need charge + discharge cycles before they work right. If the batteries are brand new and the charger LEDs are showing charging progress use the machine normally. After 10 charge/discharge cycles the charger and batteries should work correctly.