Approaches to Evaluate a Charger

Introduction

Chargers manage voltage and current to refill, or recharge, a battery according to the manufacturer's specifications. While simple in concept, a charger may be required to change its output characteristics, detect and test batteries before or during charge, or even require communication with the battery or the utility company. Chargers range from a simple charger which provides only a constant current (CC), constant power (CP), or constant voltage (CV) output all the way up to a grid-managed charger which changes how it charges the battery based on utility, battery, and additional conditions. This applications note provides a basic description as to each charger and some information about the best way to evaluate each type.

Always On Chargers

Always on chargers typically provide a fixed output. For example, a lead acid trickle charger provides only a small constant current (CC) output. This type of charger can be verified by using an electric load with either constant voltage (CV) or constant resistance (CR).

In rare cases, this type of charger may provide either CC or CV during the charge profile. In this case, the electronic load can still be used by using a constant resistance (CR) loading.

All NH Research loads support CC, CV, CP, and CR allowing maximum flexibility in evaluating always on chargers.

4350 Load and a simple charger

Waking up a Charger

Battery chargers may not provide an output voltage or current until it first detects the voltage from the battery, an external interlock is closed, or both. The charger may even use these battery detection conditions in order to determine how to safely start charging the battery. For example, the charge profile may wait until the temperature reaches an acceptable level or contain additional pre-charge steps to recover deeply discharged batteries.

In these cases, the test fixture may contain a small power supply, diodes, or relays needed to "wake-up" the charger. All NH Research air-cooled loads provide digital I/O allowing additional test fixture devices to be managed by the load.

We provide connections that allow a turn-on signal to be used to either a charger or a small power supply. Or control a relay / switch to connect the power supply to the charger just to start it up then disconnect it later.
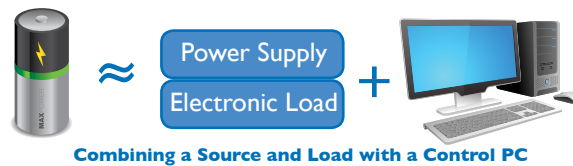
Examples:

Turn On Signal

Power Supply

Turn On Signal
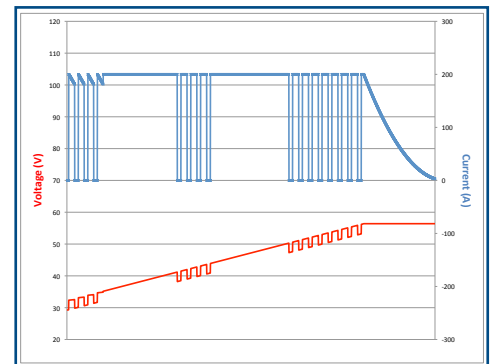
Chargers That "Test" the Battery (During Charge)

Chargers may "test" the battery during charge by reducing or even drawing power from the battery itself. Some types of batteries require these "tests" for the charge to be properly accepted, to reduce internal pressure, or to re-absorb chemicals within the battery itself. Alternatively, some chargers do these "tests" in order to safely charge the battery, to determine the health of the battery, or for self-calibration of the charger itself. How the charger "tests" the battery and what the charger expects to see in a normal battery determine the approach used in validation.

Combining a NH Research load with a power supply along with a control application on a PC can be a very cost effective solution for low power chargers (<6kW) especially when the charger does not require a quick response from the simulated battery. In this case, the PC adjusts the power supply and load to simulate the increasing battery voltage as it is being charged.
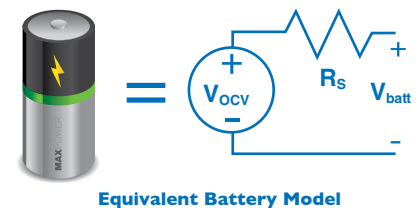
Combining a Source and Load with a Control PC

The PC can be programmed to control the power supply and load to emulate how emulate how a battery actually behaves any time the charger preforms a "test" of the battery. In this case, the PC continuously measures the voltage and current being delivered by the charger then, as needed, adjust the power supply and load to emulate the battery's response. This process is then repeated throughout the entire simulated charge profile.

A more direct approach can be implemented by first understanding why a battery changes it voltage due to changes in charge current.

The voltage seen at the terminals of a battery decreases slightly as a charger reduces, or even reverses, the charge current. Similarly, the voltage at the terminals of a battery increases slightly as the charger supplies additional current. Both of these effects are caused by the internal resistance of the battery chemistry and the wire connections.

Equivalent Battery Model

The NHR 9200 Battery Test System provides a battery mode allowing programming the series resistance (R_S) and a no-load open circuit voltage (V_{OCV}). When programmed, the system automatically adjusts the output terminal voltage based on the direction and level of current flowing to, or from, the charger.

$$V_{batt} = V_{ocv} + R_s \cdot I_{charge}$$

The adjustment is being handled in hardware improving the simulation speed, removing the integration complexity, and allowing the PC to focus on the test. In addition, the charger remains in control of the terminal voltage and current at all times even when it changes between CC, CP, or CV.

Charger Output Controlled by BMS data

As discussed above, the charger can and will change its output to meet the manufacturers charge specifications or to ensure that a battery is charging properly. Many chargers today actually communicate with the battery, utility company, or both. Charging stations are being developed to enable power flow from the vehicle to grid (V2G) in order to assist the grid by stabilizing frequency, reduce peak demand spikes, or provide temporary backup.

In this application, the charger communicates with the battery management system (BMS) and will adjust its output based on the battery data or control information returned. This approach is found in chargers of all sizes including laptop, in-vehicle chargers, and wireless power transfer systems. The test station needs to emulate the battery and provide a communication interface such as I2C, SMBUSS, or CAN to communicate with the charger under test.

Electric Grid — *Vehicle Data*

Charger Output Modified by Grid Utilization

Charger output may also change due to current electric grid utilization. These grid-aware chargers may adjust its output, reducing, pausing, or even delaying charging. These chargers are able to communicate with a smart grid using standard based protocols like the smart energy profile (SEP).

Grid Data — *Electric Grid*

Vehicle to Grid Power Transfer

There are a number of initiatives for using vehicles as local backup power or to assist the utility company during periods of peak demand. In this case, the charger is reversed and acts as a distributed generator taking power from the battery and supplementing the electric grid addressing a short term power shortage, frequency shift, or other grid issues.

NH Research supplies software packages and fully documented drivers allowing them to be added to test setups for any of these applications. Contact NH Research for more information or to discuss your charger testing needs.

Electric Grid

NHR 9200 Battery Test System

- Simple chargers
- Chargers with battery detection
- Chargers with battery testing functions
- Advanced chargers

Can operate as a power supply, load, or directly emulate a battery.

Available from 12kW to 100+kW

NHR 4700 and 4760 Air Cooled Loads

- Simple chargers
- Chargers with battery detection
  (with additional power supply)
- Chargers with battery testing functions
  (paired with power supply)

Available from 1kW to 36kW
Contact factory for higher power level options

NHR 4350 Air Cooled Loads

- Simple chargers
- Chargers with battery detection
  (with additional power supply)
- Chargers with battery testing functions
  (paired with power supply)

Available from 150W to 600W

Contact factory for higher power level options

Contact NH Research for more information or to discuss your charger testing needs

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