34000A / 36000A Series

Compact High Power DC Electronic Load

Providing electric car charger and battery test solution

After several years of rapid developments and investments in new battery and electric traction technologies, the number and types of electric and hybrid vehicles is expanding rapidly.

Along with this growing field of vehicle types, infrastructure support of home chargers and rapid public electric chargers is growing fast as well.

All electrified vehicles rely on rechargeable batteries for their electrical energy source. These batteries must be charged at regular interval using either alternating current or direct current charging technology. AC charging is convenient when drawing power from the utility grid. Prevailing industry charging standards use a variety for voltage and current ratings such as 120 V / 12 A, 120 V / 16 A; 220 V / 12 A, 220 V / 16 A, 220 V / 80 A and others depending on region. For fast public charging stations, three phase power is used to shorten charging times significantly. Often, on-board AC chargers are installed in the vehicle so they can be charged from any available AC outlet although charging times using on-board chargers can be quite long as they are often limited in voltage and current capability. However, ready access to standard grid power is an important convenience.

The specifications for DC charging range from 400 V / 125 A to 250 A, 50 kW to 120 kW, 800 V / 250 A to 500 A, 150 kW to over 360 kW.

DC fast chargers are typically installed in public charging stations and can offer greatly reduced charging times due to their ability to deliver high voltage and high current at the same time for fast charging of DC batteries.

The Prodigit 34000A and 36000A Series of compact programmable high power DC loads offer 5 kW to 60 kW per cabinet DC load test capabilities up to 1000 Vdc. Models are available at various voltage, power and current combinations to meet specific battery size and voltage/current requirement as shown in the table below. These programmable DC loads were designed to support electric chargers and electric vehicle battery pack development and test and have been deployed by car manufacturers and tier 2 automotive suppliers all over the world. Of specific importance is the ability of the 34300A and 36300A load modules to operate at full rated power up to 1000 Vdc, covering all DC voltage standards used for electric vehicles.

Power / Voltage	60 V	600 V	1000 V
5 KW	34105A (1000 A)		
25 KW	34125A (1000 A)	34225A (800 A)	34325A (250 A)
30 KW	34130A (1000 A)	34230A (960 A)	34330A (300 A)
35 KW	34135A (1000 A)	34235A (1120 A)	34335A (350 A)
40 KW	34140A (1000 A)	34240A (1280 A)	34340A (400 A)
50 KW		36250A (210 A)	36350A (500 A)
60 KW		36260 (240 A)	36360A (600 A)

All 34000A and 36000A model DC loads can be equipped with an optional PLC interface for integration into charger and battery production line test systems. The PLC input accepts both digital I/O and analog 0 to 10 V scaled analog signals to control operation of the DC load. Contact Prodigit sales department for further details.

For higher levels of test integration, the Prodigit 9841 Battery Charge and Discharge integrated test system with associated test software offers both DC power and DC load capabilities for full charge/discharge testing, battery capacity (AH), power consumption and life cycle testing of automotive battery packs.

The 9841 battery charge and discharge test system can accommodate a full range of Prodigit electronic loads and has been adopted by the STC Bureau.

Battery Charging Methods

The most common batter charger mode for electric vehicle charging is to use constant current, constant voltage (CC-CV) mode. This means the battery is charged using a constant current level which allows quick charging of the battery while monitoring the battery voltages as it charges up. When the battery voltage reaches its peak voltage, the charger switches over to constant voltage mode preventing the battery voltage from reaching excessive levels. This method is illustrated in Figure 1.
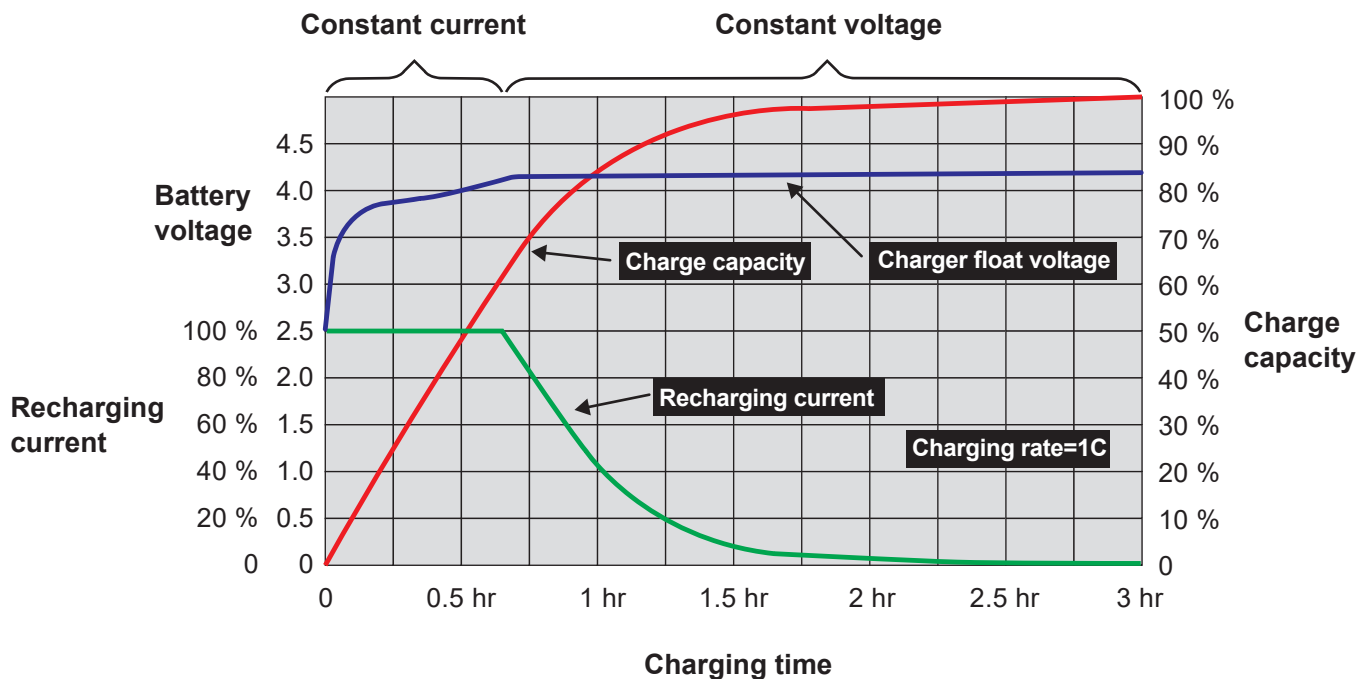
Figure 1 : shows a typical charge curve of the battery current, voltage and capacity.

Electric Vehicle Charging Station Test Method

When charging electric vehicle batteries using an on-board vehicle charger or charging station, the battery represents a load to the charger. During the charging process, the battery voltage will increase slowly. To enhance the speed of the charger to detect the battery voltage, using an electronic load to simulate a battery and its impedance during charger design will enable better and faster test verification.

For battery simulation applications, the most commonly used Load operating mode is Constant Voltage (CV) which simulates the battery voltage or Constant Resistive mode which simulates the battery impedance.

In Constant Voltage (CV) mode load mode, the terminal voltage of the electronic load is held at the CV setting voltage value. By adjusting the CV setting value, battery states ranging from fully discharged state to fully charged state can be simulated easily.

In Constant Resistive (CR) mode, the terminal voltage of the electronic load is held at the multiple of the charge current and the CR setting value. By changing the CR setting value of the load, various impedance states of the battery can be simulated ranging from fully charged to fully discharged.

As mentioned, Constant Voltage (CV) mode can be used to simulate different state of charge (SoC) conditions of a battery pack during charge and discharge cycles. This include low battery voltage, increasing battery voltage during charging and high voltage state when fully charged. During each stage, the load monitors and displays important parameters such as voltage, power (Watt) and current. At the end of charge cycle, the load will transition to CC mode to CV mode which will be evident from the load display readouts as well. This approach is much more convenient than using actual batteries to test on-board chargers or charging station operation.

Due to the wide range of electric vehicle charging standards and battery pack sizes used by a wide range of car manufacturers, the power levels and DC voltage and current combinations of the electronic loads used to test these can vary widely. Prodigit loads are available in power ranges from as little as 5 kW for hybrid vehicle charger testing up to 60 kW for all electric long driving range all-electric vehicle charger testing. Full test verification can be achieved by selecting the correct load model from Prodigit wide range of models. If more than 60 kW is required, two or more electronic loads can be paralleled to obtain even higher power levels.

All 34000A/36000A Series electronic loads are equipped with built-in Over Power Limit (OPL) protection circuits to ensure safe operating when used in parallel mode. The purpose of the OPL feature is to limit the power to the load when the charger output power exceeds the maximum power rating of the load. In that case, the electronic load will automatically limit the input power at or near its maximum power specification and continue to operate at this power level. The OPL function allows two or more electronic loads to be used in parallel for high power applications.

For example, a 20 kW charger can be tested using a 25 kW rated electronic load to apply over current, over power conditions to the charger under test. If a 20 kW rated electronic load is used instead, no charger over power conditions could be tested.

In case only a 20 kW electronic load is available, a 5 kW load model can be added at any time to be used in parallel with the original 20 kW load in Constant Voltage (CV) or Constant Resistive (CR) mode of operation. His is illustrated in Figure 2. This is due to the Prodigit load's OPL function which allows CV or CR mode with parallel loads of unequal power ratings. This capability offers great flexibility in deploying multiple loads for a wide range of power requirements.
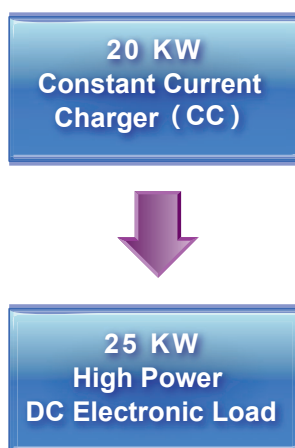
20 KW Constant Current Charger (CC)
↓
25 KW High Power DC Electronic Load

Figure 2 : Single charger connects to a single load

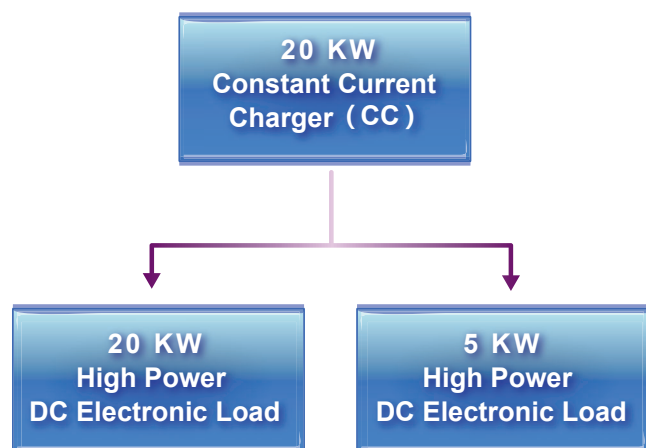| 20 KW Constant Current Charger (CC)	
20 KW High Power DC Electronic Load	5 KW High Power DC Electronic Load

Figure 3 : Single charger connects two loads in parallel

Electric Vehicle Battery Test Methods

Once an electric vehicle's battery is fully charged, it can be driven till almost depleted for maximum driving range. In drive mode, the battery acts as a power source for the electric drive train.

Battery charge and discharge times and associated battery life are important considerations for electric vehicle designs. Another critical design criterion is safe operating area of the battery pack which relates to minimum and maximum charge and discharge voltage levels. For example, a single lithium-ion battery cell's charging voltage cannot exceed 4.2 Vdc to prevent overcharging while the discharge voltage cannot drop below 2.5 Vdc to avoid excessive discharge. Both conditions can dramatically affect battery life and quickly and permanently damage the internal structure of the battery cell. Therefore, during development and test, careful attention must be paid to charging and discharging voltage levels to avoid permanent battery damage or deterioration.

Prodigit 34000A/36000A Series DC loads offer the following four operating mode to assist in avoiding conditions during battery discharge testing that could result in permanent battery due to over of under voltage.

1 CC+CV mode is aimed at battery discharge testing.

In this mode, discharging of the battery starts in CC mode of operation by setting a current discharge level (CC Set point) and a discharge stop voltage level (CV Set point) which determines full state of charge for the battery under test. When the battery voltage drops to the CV set point level, the electronic load stops discharging so that the battery voltage is maintained at the CV set value. Operation in CC+CV mode is very straightforward as the load automatically switches from CC constant current mode discharge mode to CV constant voltage mode. This prevents the battery from being damaged due to excessive discharging. This mode of operation is illustrated in Figure 4.
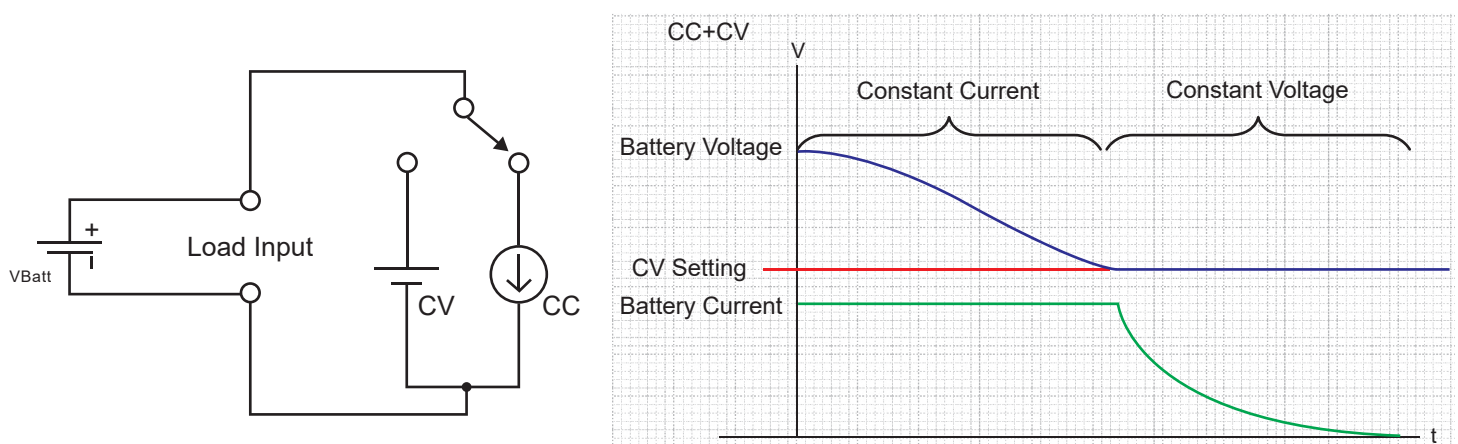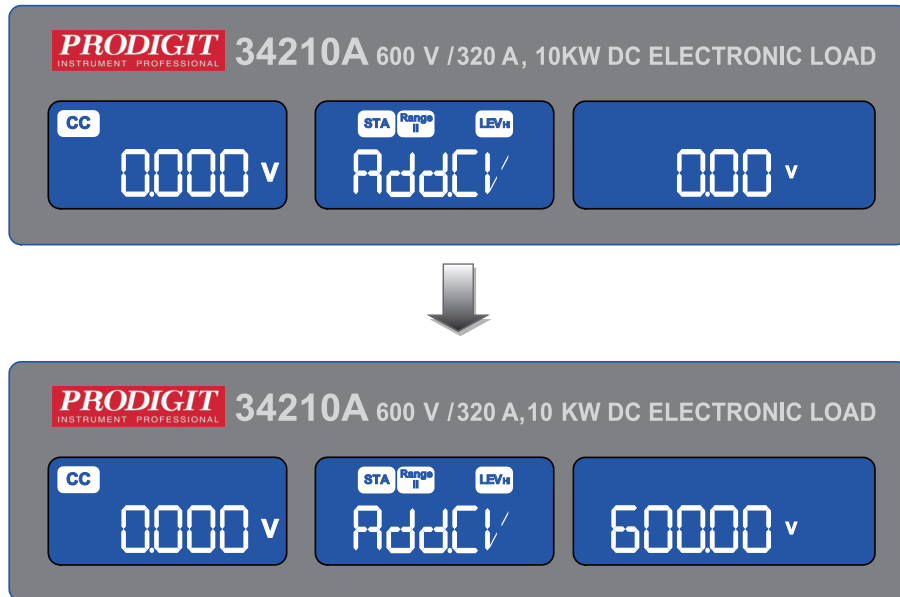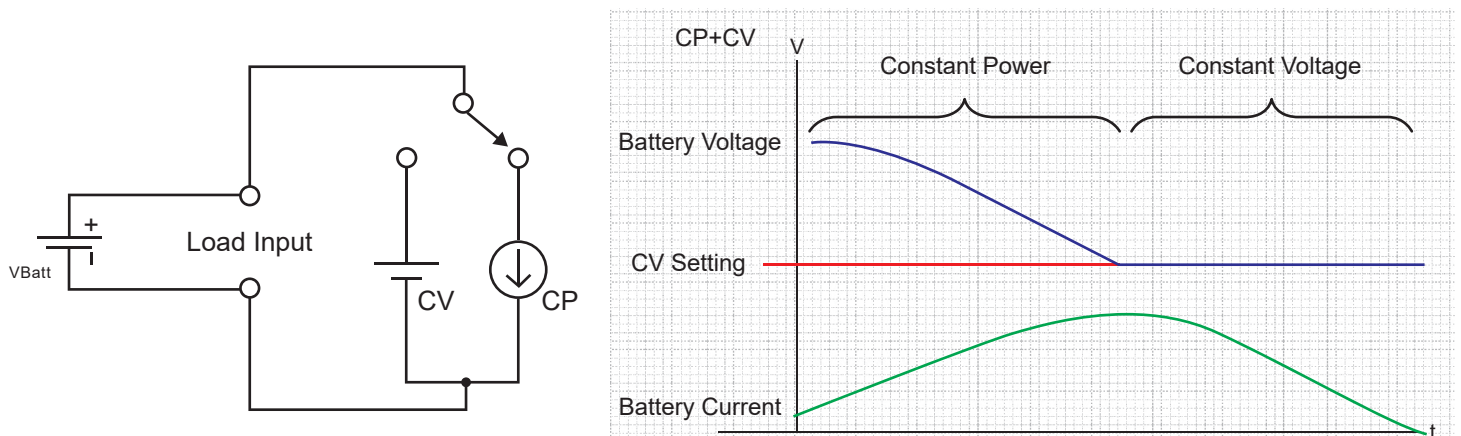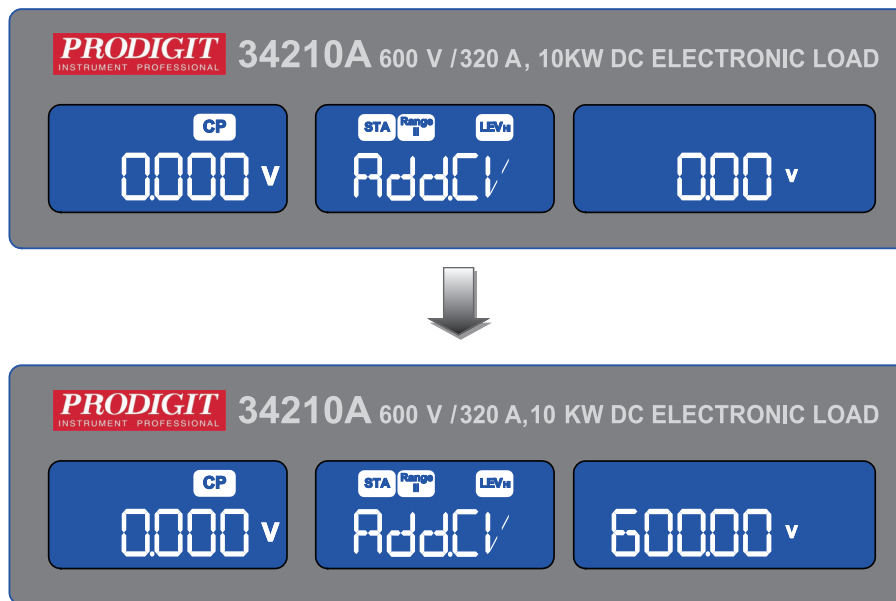

Figure 4 : Application of CC+CV operation mode

- Load input terminals are connected to the DUT
- Change to CC mode and setting CC current setting.
- Press Limit key to setting the CV voltage and the display will show "Add.CV".
- Press START key to start up the CC+CV test, and press "STOP "key to stop CC+CV Test.

The LCD display shows Add.CV function

2 CP + CV mode battery discharge test

In CP + CV mode of operation, the electronic starts discharging the battery using a constant amount of power drain as determined by the CP set point. Once the battery voltage sags to the CV set point, the load transitions from CP mode to CV mode to maintain the discharged state battery voltage.

Operation in CP+CV mode is very straightforward as the load automatically switches from CP constant power mode discharge mode to CV constant voltage mode. This prevents the battery from being damaged due to excessive discharging. This mode of operation is illustrated in Figure 5.

Figure 5 : Application of CP+CV operation mode

- Load input terminals are connected to the DUT
- Change to CP mode and setting CP power setting.
- Press Limit key to setting the CV voltage and the display will show "Add.CV".
- Press START key to start up the CP+CV test, and press "STOP "key to stop CP+CV test.
- Setting CC+CV or CP+CV upper limit voltage, Middle 5 digit LCD display「Add.CV」, right 5 digit LCD display the unit is "V" , The Add.CV set range from 0.00 V to 600.00 V step 0.01 V by rotating the Setting knob.

PRODIGIT INSTRUMENT PROFESSIONAL **34210A** 600 V /320 A, 10KW DC ELECTRONIC LOAD

| CP | STA Range II LEVH | |
| 0.000 v | AddCV | 0.00 v |

PRODIGIT INSTRUMENT PROFESSIONAL **34210A** 600 V /320 A,10 KW DC ELECTRONIC LOAD

| CP | STA Range II LEVH | |
| 0.000 v | AddCV | 600.00 v |

The LCD display shows Add.CV function

③ CC + UVP mode battery discharge test

In CC + UVP (Under Voltage Protection) mode of operation, the electronic starts discharging the battery using in constant current mode with a current drain determined by the CC set point. Discharging will continue till the battery reaches the Under voltage protection point as set by the UVP set point. At this point, the total amount of Ampere Hours drawn from the battery will be display in AH and no more discharging occurs.

Operation in CC+UVP mode is very straightforward as the load automatically switches from CC constant current mode discharge mode to OFF mode. This prevents the battery from being damaged due to excessive discharging. This mode of operation is illustrated in Figure 6.
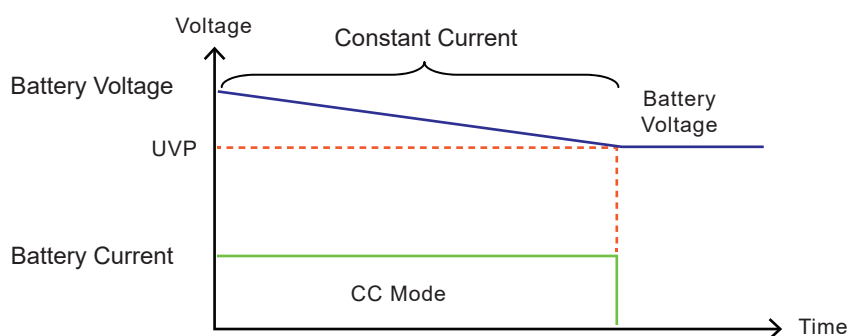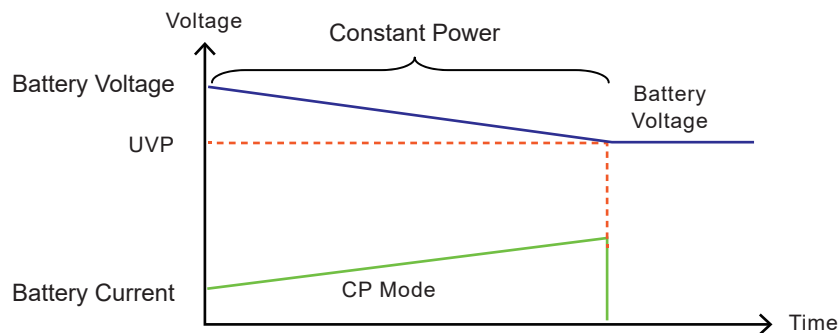
Figure 6 : CC + UVP mode battery discharge test

1. To setting loads current on Constant current (CC) mode.
2. Press Config key to BATT1 and setting the UVP voltage.
3. Press Start key to do the BATT1 (CC+UVP) test

   When external battery voltage is less than UVP (under voltage protect) setting values, The Load ON LED is off to indicate Load off status, and displays the total discharge stored energy of the AH. Note : when in remote control mode, the front panel does not display the total discharge capacity but this information can be queried over the bus.

4 CP + UVP mode battery discharge test

In CP + UVP (Under Voltage Protection) mode of operation, the electronic starts discharging the battery using a constant amount of power drain as determined by the CP set point. Discharging will continue till the battery reaches the Under voltage protection point as set by the UVP set point. At this point, the total amount of Ampere Hours drawn from the battery will be display in AH and no more discharging occurs.

Operation in CP+UVP mode is very straightforward as the load automatically switches from CP constant power mode discharge mode to OFF mode. This prevents the battery from being damaged due to excessive discharging. This mode of operation is illustrated in Figure 7.

Figure 7 : CP + UVP mode battery discharge test

1. To setting loads power on Constant Power (CP) mode.
2. Press Config key to BATT1 and setting the UVP voltage.
3. Press Start key to do the BATT1 (CP+UVP) test

   When testing loads on of Constant Power (CP) mode, battery voltage is less than UVP Setting values, The Load ON LED is off to indicate Load off status, and displays the total discharge stored energy of the AH .

In addition to the four battery discharge test modes described above, the 34000A/36000A electronic loads also support pre-set discharge time interval setting and pulse current discharge modes. Discharge current can also be programmed to follow a set step or ram pattern as needed. A sample discharge current waveform is shown below. These specific discharge profiles can be used to simulate actual driving conditions dependent battery discharge profiles to test and evaluate battery performance and life-span.

5.1 Time period discharge

In time period discharge mode, the total discharge time is programmed on the load by the user as shown in Figure 8. When the discharge time reaches zero, discharging is stopped and the discharge time and end of discharge battery voltage will be displayed. Programmable range for discharge time interval ranges from 1 second to 99999 seconds or 27 Hours.
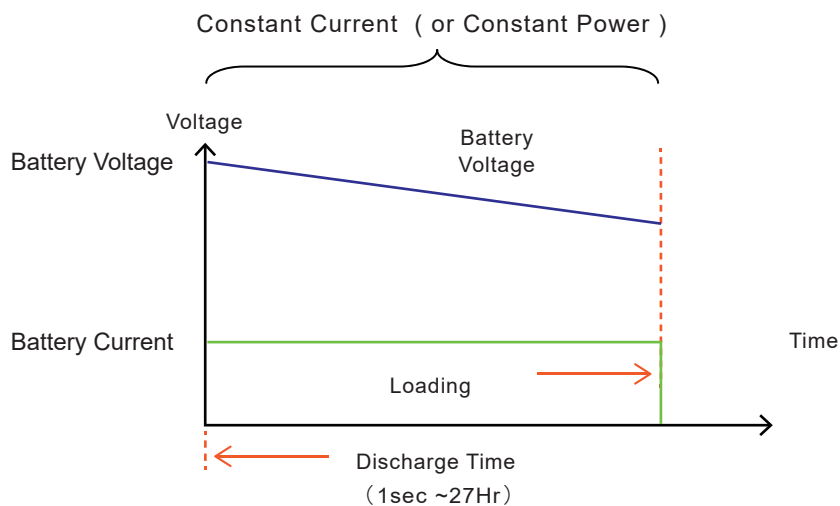
Figure 8 : Setting discharge time battery discharge test

Operation Procedure

1. To setting loads current or power on Constant Current (CC) or Constant Power (CP) mode.
2. Press Config key to BATT3 and setting the discharge time.
3. Press Start key to do the BATT3 (CC/CP + discharge time) test
   When testing loads on of Constant current (CC) or Constant Power (CP) mode, when discharge time achieve setting time, this moment the load on auto change to load off and display battery voltage.

5.2 Pulse discharge

The current test of pulse discharge, use pulse mode for battery discharge test, and use DYNAMIC MODE to test + Repeat Function, as shown in Figure 9 test LOAD ON, DYN ON to COUNTER = 0 to the end, when end LOAD OFF, DYN OFF. For details please contact PRODIGIT sales.
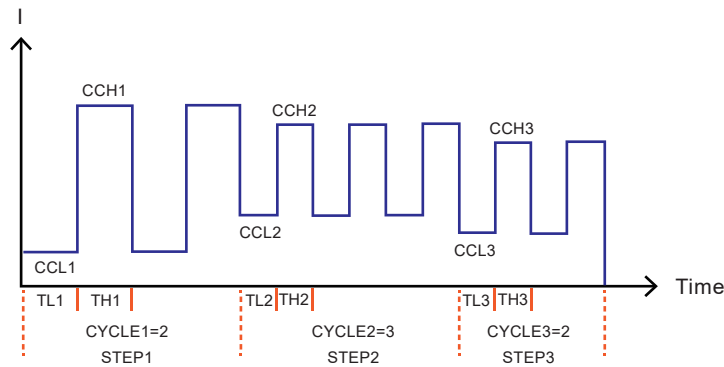
Figure 9 : Pulse current discharge / battery discharge test

5.3 RAMP discharge

RAMP mode discharge test, Slew-Rate sink current + Repeat function,

as shown in Figure 10. Please contact PRODIGIT sales for detail operation of RAMP mode.
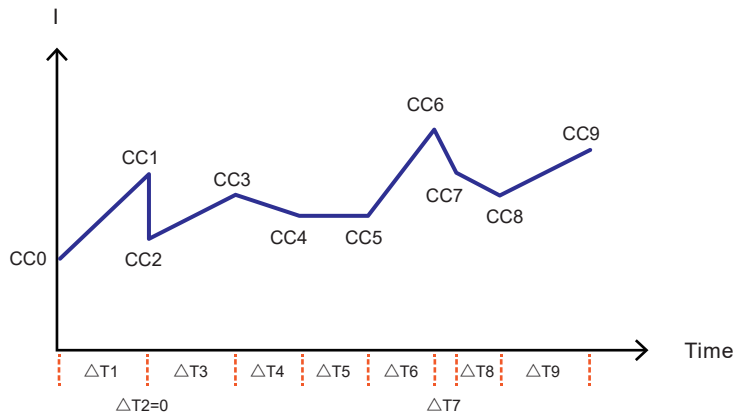
Figure 10 : Ramp mode battery discharge test

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