

## PS2420 Multi-Stage Charge Algorithms

- There are up to 8 charging Stages! Depending on the MODE selected, these stages are already preset and implementation of each stage will vary from one MODE to the next, dependent on the type of battery intended to be charged. These charge stages 'typically' include:
- **PRE-QUALIFICATION-TEST Charge Stage:**
  - Tests battery for sulphation by applying a low level charge current and analyzes voltage and current values and rates of change to determine if the battery is ready to transition to the next high power Bulk Charge Stage. If a Battery Temperature Cable is installed, then minimum and maximum temperature automatically become part of the analysis.
- **BULK Charge Stage (also known as 'Constant-Current'):**
  - High Power charge, charges at a constant current or constant power rate to deliver the 'bulk' of the charge needed. Some algorithms employ a 2-step Bulk Charge rate where a timed 10 to 30 minute period of a higher current may be measured. This two-step process helps to break down sulphates quicker. Upon completion of this stage, approximately 80% of total charge is delivered to the battery.
- **ABSORPTION Charge Stage (also known as 'Constant-Voltage'):**
  - Charger charges at a constant voltage level to provide adequate time for the battery plates to 'absorb' the energy delivered. Charge Amperage decreases as the energy is being absorbed into the plates. Termination of this stage occurs when the charge current has decreased down to a targeted value which is dependent on many factors such as size, type, age, and chemistry of battery. Upon completion of this stage, approximately 95% of total charge is delivered to the battery
- **TOP-OFF Charge Stage (also known as 'Finish'):**
  - Charger charges at either a constant voltage, or constant current, or a combination of constant-current / constant voltage to 'Top-Off' the charge in a battery. Variations in this charge stage are highly dependent on the battery Charge MODE selected. Flooded Lead Acid batteries are typically aggressively charged to high voltage levels to force internal gassing which helps to mix the electrolyte. AGM (Absorbed Glass Mat) batteries differ in that this stage limits upper voltage regulation levels which helps prevent drying out the Absorbed Glass Mat. Upon completion of this stage, approximately 100% of total charge is delivered to the battery.
- **EQUALIZATION Charge Stage:**
  - As batteries in a battery pack charge and discharge over many cycles, cells may become unbalanced. Cell unbalancing becomes more common as batteries age. This stage employs Timers in combination with  $dv/dt$  and/or  $di/dt$ , and/or  $dT/dt$ , and/or, maximum voltage and temperatures (if Battery Temperature Sensor installed), to terminate. Even if this stage is activated in a charge MODE, it is not applied during every charge cycle. For lithium and GEL batteries, Equalization is not applied and cannot be manually selected. Manual (intentional) selection of this charge stage, by the user, can be selected by depressing and holding depressed the 'Menu Select Button' for 10 seconds WHILE A.C. Power is applied. If the Menu Select Button is again depressed and held depressed for 10 seconds, this stage will toggle off. The charge cycle, in which this additional Equalization Charge Stage will inject itself into, will be announced by either flashing the Red Power On LED or flashing the LCD Backlight, continually throughout the ENTIRE charge cycle. The flash will stop upon entry into the Float/Maintenance Standby Stage

- **FLOAT/MAINTENANCE STANDBY Charge Stage:**

- The entry into this stage typically signifies that the battery is FULLY charged and has a Green LED 'Charged' indicator associated with it. On an LCD display, the status will display as 'FLT'. No further charging action occurs. However, all batteries, regardless of chemistry, self-discharge at a rate that is proportional to ambient temperature meaning that if a battery sits on a table completely disconnected from all loads, it will self discharge over many months.

This charge stage, depending on the MODE selected will accomplish one of the following:

- Regulate at a low voltage level to supply a 'trickle current' to 'MAINTAIN' battery at full (prevent self discharge).
  - Disconnect itself from A.C. Power by disabling the internal relay, and allow the battery voltage to 'FLOAT' for 45 days, at which time, the charger will automatically re-initiate, a new charge cycle and automatically reconnect to A.C. Power, or re-start charging if the battery voltage decays below a trigger voltage level
- If the charger is fitted with an internal A.C. Connect/Disconnect relay, typically, the output is allowed to 'FLOAT' and not regulated, which prevents the consumption of utility provided power. During this stage, regardless of the use of an A.C. Relay, the microprocessor continues to monitor the battery and passage of time while in this 'STANDBY' stage. The charger may be left connected to battery with the A.C. Power Removed. The amount of drain from the battery is very minimal.

- **Common Traits Applied to All Charge Stages:**

- Each Charge Stage employs the use of a 'Safety Timer' to time out and end that stage if the stage process took too long without achieving the desired targeted results. Upon Safety Timer time out, a decision is automatically established to transition to the next stage, or advance immediately to the final stage – Float/Maintenance Standby Stage, or terminate charge and display an Error Code.
- Each charge stage employs  $dv/dt$  and/or  $di/dt$  signal analysis to monitor the progress of charging and factors into the termination of the stage.
- If a Battery Temperature Sensor Cable is installed, the charger automatically detects its presence and will use it to adjust voltage and current charge rates during the deployment of the charge algorithm. For example, if charging in a cold temperature climate, the charger will increase the voltage level targets to compensate for the temperature. If the climate is hot, the regulation targets decrease automatically – this is also known as 'Temperature Compensation' and is typically adjusted to  $-2mV$  to  $-6 mV / cell / ^\circ C$ .
- Some Stages may not be applied. For example, Lithium Based Battery packs employ the use of Battery Management Systems and will not work if a Pre-Qualification-Test Stage is used. Therefore, when selecting a Lithium Charge Stage, Pre-Qualification Test Stage is automatically not employed.