Solar Solutions
Total Charge Technology

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System Test Plan for an Advanced Function Maximum Power Point Tracking Battery Charger for 12 Volt Lead-Acid and 16 Volt Ni-Cad Batteries

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System Test Plan

Preliminary Power Supply Tests

- The first circuits to be tested shall be the 5V, 3.3V and isolated power supplies. Voltage in the operational range of the device shall be supplied to these components and their output voltages verified with voltmeters. We shall place load resistance on the rails to simulated load conditions and verify correct operation under load.

DC/DC Conversion Tests

- A special breakout port has been added to our design attached to the gate-drivers of the MOSFETs comprising the buck-boost converter. To verify correctness of the converter, a 10V supply limited to a few amps shall be placed on the input of the converter, where the solar panel would typically be attached, and a resistive bank shall be placed on the output, bypassing all current limiting and protection circuitry on the output for the moment.
- The gates shall be pulsed at some pre-determined duty cycled produced on a function generator. If the circuit is functioning as expected we shall expect the output voltage to follow the input voltage according to the well-known buck-boost voltage transfer.

Buck/Boost Sensors Test

- Once the Buck-Boost has been verified, current probes shall be placed on the input of the 10V supply and freewheeling diodes in the buck-boost converter to determine if the hall-effect sensor is capable of correctly traducing currents.
- At this stage we shall also verify that our voltage converters are correctly sensing the voltage.

Microprocessor Test

- Once the operation the Buck-Boost and the respective sensing circuits are determined we shall attempt to remove the jumpers connected to the gates-drivers and drive the buck-boost gate drivers from the onboard microprocessor.
- We shall first start with a very simple open loop PWM routine, and verify correct operation. We shall expect our output voltage to follow the input voltage within reason during this period.
- Once open-loop operation has been verified we shall implement the closed loop PWM algorithm. With the loop closed, we expect to see the output following the input voltage much more closely. General tests shall be done such as to determine general behaviour of the system under known conditions. The sensing and control parameters shall be tuned during this stage.

MPPT Testing

- Once the converter has been verified to work with a closed loop we shall now have successfully designed a buck-boost DC/DC power supply with no protection circuitry. Replacing the input DC power supply with a solar panel, implement MPPT algorithm on the microprocessor and placing a battery across the output terminals of the buck-boost shall covert this power supply into a MPPT charger.
- We must be careful at this stage because protection circuitry will be the last thing we shall test as they are least crucial to the operation of the device. Placing the battery with reverse polarities or short-circuiting the battery internal to the converter shall be catastrophic.
- Before we commence testing of the MPPT system with a solar panel, we shall directly connect a solar panel to a battery and measure charge power. We shall use this as a reference. Once we place the Helios MK1 between the solar panel and the battery we expect to see higher power draw from solar.
- If this condition is not met, our design is an utter failure. as much time as possible will be placed to rectify said issue in order to increase power draw versus control condition.
- The voltage across the panels shall be observed and verified to be at least somewhat stationary. If wild ~5-20V oscillations are present across the solar panel, it would indicate faults in one of the subsystems.
- The first step to overcome this issue would be to repeat what was done when the operation of the DC/DC buck-boost sub-circuit. We shall drive the gate-drivers with a known PWM signal, bypassing the microprocessor and all sensing circuitry. At this stage we would expect to be able to control the voltage across the solar panel as a function of the duty cycle of the PWM and the battery voltage. In the unlikely case this condition is not met we must trace the error and fix it.
- If the MPPT system successfully works, as in we are drawing more power with the converter than without from the solar panel, our product is at least to some extend a success. further tests must be done with a previously characterized solar panel (I-V curves measured or given by manufacturer) to verify correct MPPT. The lack of "concrete" fixed variables in our system due to the extremely dynamic nature of the MPPT charger makes it difficult to say without a doubt that MPPT is achieved, however we shall at the very least expect to get noticeable improvement of the output current when the

“Bonus” Tests

Once we have achieved our main goal of MPPT charging of a battery, we shall do further tests. Components will be tested for their safety, reliability, efficiency, and correctness of numerical values as stated on datasheets. More important components shall warrant a more intense testing. Individual components will be tested prior to assembling the device to ensure overall success.

Further testing on parts includes the following.

- Inductor: Efficiency of energy conversion
- Power Supply (Brick): Brick supplies enough power to the active components
- Current Sensors: Sensed current is accurate with little variance
- Fuse: Fuse will open during over currents and will not have false triggers
- Crowbar: Crowbar will activate upon overvoltage and will not have false triggers
- Can the charger damage the battery or overcharge the battery?

Because of the harsh climate in British Columbia, temperature testing is important. The PCB will be tested in a temperature chamber; efficiency of operation throughout the required specified operating region shall be tested. EMI levels will also be tested in an EMI chamber.

- Charger will maintain all functionalities at all temperatures within specification.
- Charger will not produce significant levels of EMI.

Once the device has been thoroughly tested in a lab environment, it shall be placed outdoors and monitored to check for MPPT effectiveness, component temperatures and overall ruggedness. Such testing requires significant resources and maintenance. Therefore, prolonged outdoors testing is slightly more difficult to conduct because of time restrictions. Without testing the system for extended periods of time in typical environments, it is difficult to gauge the true long-term performance of the device. Never the less, as long as MPPT, or at the very least power extra power is drawn from solar panels, over an expected operation range, we shall consider the Helios MK1 a success as far as this course is concerned. Significant efforts have been placed to meet EMI, temperature ruggedness and safety requirements; however, these requirements are secondary to the MPPT charging of the battery.