Constant Current Battery Load Discharger and Tester

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Abstract

The goal of this research project was to gain knowledge and experience of electronic design through construction of a device at the component level. The Constant Current Battery Load Discharger and Tester uses analog electronics to regulate the draining of a battery so the battery voltage and capacity characteristics can be analyzed. Current regulation is achieved using a comparator to equalize the analog voltage on its feedback input with an analog voltage on its reference input. The reference voltage is set via a potentiometer, while the feedback voltage is current sensed through a 100 mΩ resistor, which is loading the battery. A separate comparator is responsible for comparing the battery voltage with a potentiometer-adjusted minimum reference value and disconnecting the load before over-discharge of the battery occurs. An onboard computer interface can be used to help set and monitor discharge conditions as well as record test data.

Keywords

Undergraduate research, Battery testing, Electronics, Power electronics, Undergraduate student poster.

Introduction

Both literally and figuratively, a battery can be considered a black box. While batteries do a great job at powering our RC toys, security systems, and lawn mowers, it can be hard to troubleshoot them when there is an issue because they offer no convenient indication of charge or life. Very precise tests with rather uncommon equipment would be required to truly determine a battery's longevity or performance under specific conditions or after degradation. The battery would have to be drained at a constant rate from full charge. Additionally, battery voltage and test time would have to be monitored for analysis. Devices to perform such tests do exist but in many cases are very expensive and provide output of the battery's result that is neither accurate nor specific enough for the tester's needs.

In late 2021, a device was conceptualized to offer a solution to this problem. The device would be suitable for testing a wide range of battery sizes and types. The device would be easy to use, safe, and supply a graphical output of the battery's voltage over time. The project would offer a perfect learning opportunity in the field of digital and analog electronics while producing a useful piece of lab equipment. This device was called the Constant Current Battery Load Discharger and Tester and was chosen to be a project for the 2022-23 Opportunity for Undergraduate Research Experience (OURE).

Overview

The project block diagram seen in Figure 1 was designed according to the necessary electrical sections but also somewhat resembles what the final product would look like. All component level electronics for this project would be located on a single PCB with the exception of the MOSFET load. The load would need to dissipate a great deal of thermal energy, so it would be connected to a large heatsink mounted on the project's chassis. Switches and adjustment knobs would need to be placed at the front of the board because that would be the most convenient for the user. Battery terminals would be placed close to the load terminals because it is desired to keep high current conducting traces as wide and short as possible to reduce loss.

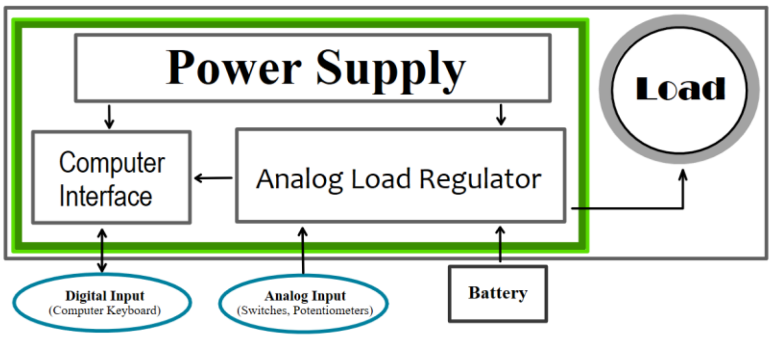

Figure 1: Device Block Diagram.

Although the project can function independently from a computer, research into a computer-based method of data acquisition was included for user convenience. The device features a USB-mini port which, when connected to a computer, allows the computer to act as a sort of PuTTY-based test terminal [1]. Before a session is started, the terminal asks the user to acknowledge a battery's start voltage, set the cutoff voltage, and set the constant current level before pressing Start on the device. After a test session is started, battery voltage samples are taken and sent to the terminal as seen in Figure 2. After a test is complete, this data can be extracted and graphed for analysis.

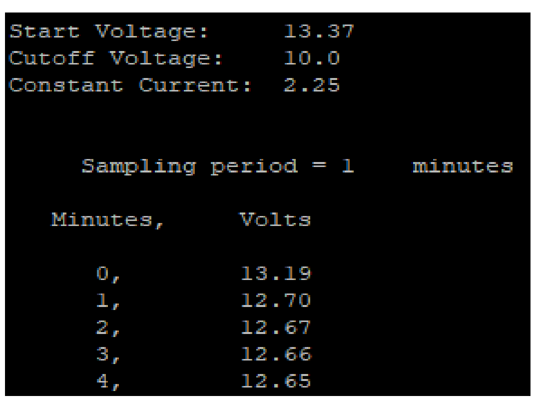

Figure 2: Test Terminal Session Mode

The device PCB was constructed using computer animated design software and ordered through a manufacturing company. Although the physical design of the PCB was relatively strait forward, a specific technique called a kelvin connection was required for the sense resistor. This connection is required because a traditional connection could lead to inaccurate current regulation due to trace resistance [2]. Completed project and test setup can be seen in Figure 3.

Figure 3: Completed Project.

Initial testing of the device was planned after acquiring a UB1290 12V lead acid battery. This battery was not new but instead expected to be degraded because it was found in an electronics recycling bin. To determine whether the battery could still be considered in good condition, it was drained by the Constant Current Battery Load Discharger and Tester. The data sheet for this battery stated that the expected life for the battery, if draining to 10V at 0.25C, would be 3 hours or 180 minutes [3].

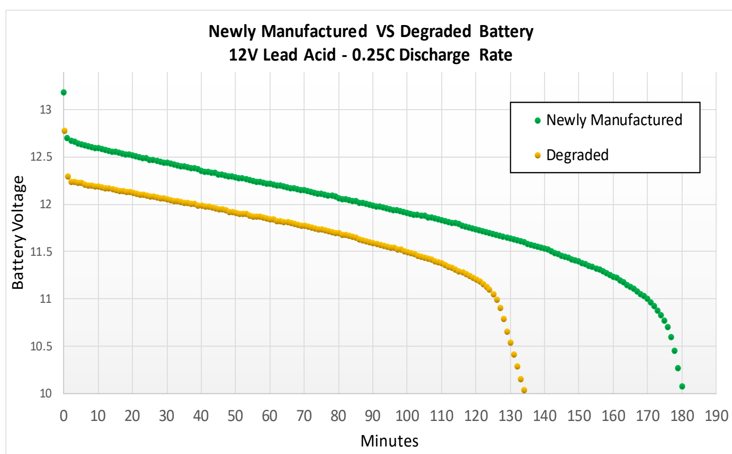

Figure 4: Comparison between tests of identical battery.

Testing of the degraded battery, seen in Figure 4, resulted in the battery being depleted just after 130 minutes. This would not match the 180 minutes specified by the datasheet and therefore it could be concluded that the battery is no longer in good working condition. Just to be sure of the results, a brand new UB1290 battery was acquired and tested. Figure 4 shows a comparison between the two battery tests. Additionally, you can see that the brand-new battery matches the datasheet exactly [3].

In conclusion, the device was successfully used to gather battery data, normally tricky to obtain, in a convenient and user-friendly manner. The project resulted in a great piece of lab equipment that exceeded expectations in performance and reliability. The practical knowledge gained by overcoming the project's challenging design and construction will surely be put towards future academic and professional projects. More research into control systems and feedback compensation will be conducted so that, one day, the project could be adapted to test a variety of input sources that may have oscillating or even alternating outputs.

Acknowledgements

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