Monitoring battery performance

Monitoring battery performance in magnetically noisy environments using fluxgate magnetometers

Courtney Dyer Terry Dyer

Abstract

The most important factors in battery technologies are battery performance and reliability. A challenge in battery research is nondestructive diagnostic measurements of rechargeable batteries during charging and discharging cycles. Currently, battery manufacturers use electrochemical testing and 2D x-ray scanning as industry standard [1].

- In this poster, I have measured the magnetic field generated by the current flow through a rechargeable battery using a fluxgate magnetometer in a magnetically nosiy environment.
- This technique demonstrates that fluxgate magnetometers can be used to monitor the charge and discharge of rechargeable batteries and thus monitor the performance and reliability of the battery over time. This technique is directly applicable to electric vehicle (EV) batteries.

Motivation

- The techniques currently used in battery diagnostics tend to be used in-situ but do not give comprehensive quantitive data, rather they provide a detailed physical surface image [2]. Also, research measurements tend to be taken using magnetic shields which decrease the magnetic noise surrounding the battery allowing the charge/discharge to be easily shown [3].
- However, magnetic shielding is not viable in the application of batteries so testing under these conditions does not consider the magnetic fields that surround batteries in 'real' situations such as electric car batteries and cell phone batteries. This was considered in the project. Therefore, in order to record 'real' measurements for magnetic field, the readings were taken in an environment with magnetic noise

Methods

- A custom fluxgate magnetometer platform has been developed at the University under Faraday Institution project FIIF006.
- The Noise floor = 20pT/√Hz @ 1Hz
- Axis of sensitivity was positioned approximately 2cm from the USB cable to a rechargeable battery.
- The fluxgate measures vector magnetic field changes in the background magnetic field, including that of Earth's magnetic field and magnetic field noise related to human activity (Fig 1).
- I became familiar with Arduino C++ and Python, both were used to control and readout data from the fluxgate magnetometer.

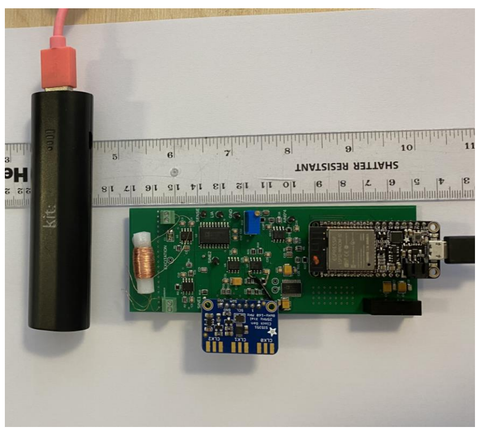

Figure 1

Analysis & Results

- The recorded data for the charge, discharge and background magnetic field was plotted against time as shown in Fig 2. The background noise was kept as close to zero as possible, this was achieved by positioning the magnetometer carefully such that the DC offset, due to the Earth's magnetic field, was nullified. This allowed the magnetic field due to the battery charge/discharge cycles to be observed.
- As the battery charges, we see a change in the magnetic field to a positive magnetic field value and as the battery discharges, we see the opposite with the magnetic field being approximately the same magnitude as the charging field but with a negative value instead. As shown in Fig 2, the values for charging/discharging are equidistant from the background magnetic field observed.
- This is an initial measurement and further work is required to determine the full capability of this technique within EV battery diagnostics.

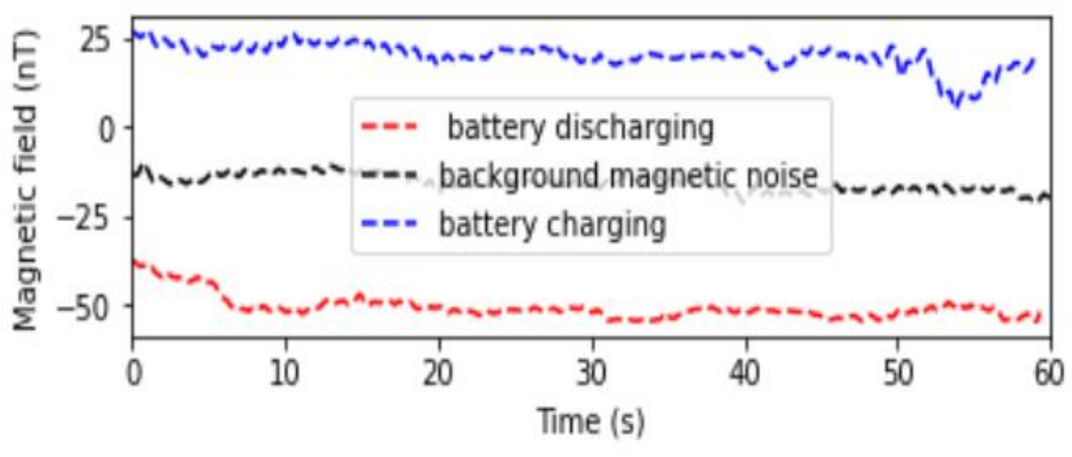

Figure 2

Conclusions

- In conclusion, the battery performance can be monitored using an in-situ fluxgate magnetometer, within an environment with magnetic noise.
- Due to the sensitivity of the magnetometer the measurements could only be taken over a short time period. However, through continued development the time period in which the measurements could be taken would increase.
- The data collected correlates with research previously published by Hu, Y. et al, thus we can show that fluxgate magnetometers can be used to determine the battery efficiency.

Impact / Next steps

- Repeat the experiment with rechargeable batteries of varying mAh ratings to ensure these results are not only applicable to the rechargeable battery used. Measuring the magnetic field over longer periods of time to measure the battery as it fully charges and fully discharges.
- In the future, these results could be verified by having another magnetometer constantly recording the background magnetic noise and then comparing the background to the charge/discharge simultaneously.

References

[1] - Hu, Y. et al., 2020. Rapid online solid-state battery diagnostics with optically pumped magnetometers. Applied sciences, 10(21), pp.1–8.

[2] - Tang, J.A. et al., 2013. Non-destructive monitoring of charge-discharge cycles on lithium ion batteries using ^{7}Li stray-field imaging. Scientific reports, 3(1), p.2596.

[3] - Hu, Y. et al., 2020. Sensitive magnetometry reveals inhomogeneities in charge storage and weak transient internal currents in Li-ion cells. Proceedings of the National Academy of Sciences - PNAS, 117(20), pp.10667–10672.

Intern bio

Courtney Dyer is studying Physics at University of Strathclyde. Interested in the development and applications of magnetometry. Aspiring to a career in industry, specifically in the renewable energies sector.

Click icon for link to personal account –

THE FARADAY INSTITUTION

University of Strathclyde Glasgow

UK Research and Innovation