Spent Battery Classification by Electrical Characterization

A. Fazakas, M. Purcar [1)] and A. C. Vonsza[1)]

Bases of Electronics Department, Technical University of Cluj-Napoca, Cluj/Romania
[1)] Department of Electrotechnics and Measurements, Technical University of Cluj-Napoca, Cluj/Romania
Albert.Fazakas@bel.utcluj.ro

Summary: Recovering raw mineral from spent batteries represents a challenge worldwide. To obtain clear, uncontaminated minerals, one of the most important tasks is to separate batteries of same size (AA or AAA) but different chemistries. This paper presents a comparative study of separation methods and proposes a simple, fast and cost effective analysis to classify batteries, based on battery impedance.

Keywords: Battery recycling, impedance, electric characterisation

Motivation and Description of Work

Recycling and recovering minerals from spent batteries is an important mission worldwide both for environmental and economic purpose. Several recycling processes, both pyrometallurgical and hydrometallurgical ones are proposed and applied for recover Mn and Zn from zinc-carbon and alkaline batteries mainly in Europe [1]

Before any milling or leaching process applied to the disposed batteries, a separation must be done based on the battery chemistry. Mixing basic electrolyte alkaline batteries with acid electrolyte zinc-carbon results in a massive ammoniac emission leading not only to environmental and health issues but also to a nonefficient recycling process.

Then aim of this work is to find a cost-effective battery chemistry classification method using electrical measurements for battery characterisation and chemistry detection

To inspect optically disposed batteries aiming to determine their type is the first thing that comes in mind. However, waste sorting systems based on optical inspection usually detect the shape of the battery versus other garbage shapes such as bottles or cans [2], being unable to recognize details such as branding or battery type form the case. Note that any of alkaline, zinc-carbon, NI-MH and even older NI-CD batteries are manufactured in both AA and AAA cases and all of these types have to be separated from each other.

The well-known method for chemistry determination is the Electrochemical Spectroscopy Impedance estimation (EIS) [3], [4]. However, the research focuses on testing the consistency of a battery pack cells. Further research focuses on determining the dynamic behaviour of the battery to extend its run time [5].

On the other hand, EIS equipment is very expensive and EIS operation is time-consuming, being unfeasible for testing large amount of batteries. Therefore, we investigate a faster and more cost-effective impedance analysis method, using Digilent Analog Discovery device Impedance Analyzer feature [6].

The DC voltage on the analysed batteries were between 0.8 ...1.2V. For each battery, a 200mV amplitude variable frequency sine wave is applied. The DC offset of the sine wave was equated to measured open-loop voltage on the battery. A 100Ω reference resistance was used on the impedance analyser.

Results

Figure. 1 presents the impedance analyser results for two alkaline and two zinc-carbon batteries.

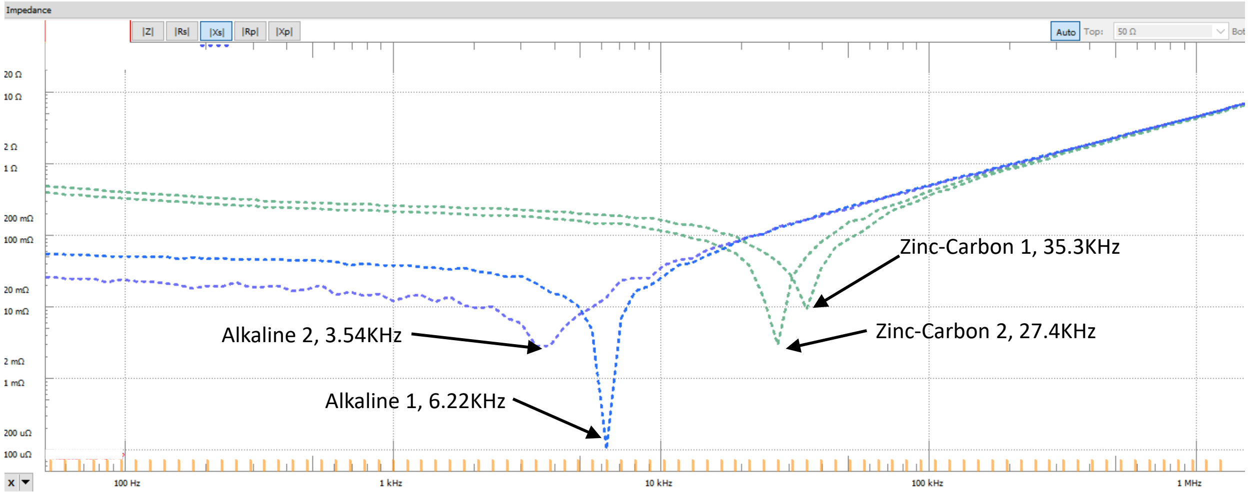

Fig. 1: Impedance analysis results of two alkaline and two zinc-carbon batteries

As expected, the internal impedance of the alkaline batteries is much lower. However, the difference between the observed resonance frequencies of the alkaline and zinc-carbon batteries is almost a decade. The resonance is mainly due the lead inductance and the battery capacities

The observed results are promising and open the opportunity to develop a cost-effective and fast method for battery classification.

Acknowledgements

This work was supported within the research program PN-III-P1-1.2-PCCDI-2017-0652, project NR. 84PCCDI - 01/03/2018 TRADE-IT.

References

[1] Francesco Ferella∗, Ida De Michelis, Francesco Veglio, "Process for the recycling of alkaline and zinc–carbon spent batteries", Journal of Power Sources 183(2):805-811, September 2008

[2] Hongyi Luo, Jiming Sa, Ruibin Li, Jin Li, "Regionalization Intelligent Garbage Sorting Machine for Municipal Solid Waste Treatment", 6th International Conference on Systems and Informatics (ICSAI), Shanghai, China, 2019, pp. 103-108, doi: 10.1109/ICSAI48974.2019.9010575.

[3] M. Abedi Varnosfaderani and D. Strickland, "A Comparison of Online Electrochemical Spectroscopy Impedance Estimation of Batteries," in IEEE Access, vol. 6, pp. 23668-23677, 2018, doi: 10.1109/ACCESS.2018.2808412.

[4] Jee-Hwan Jang et al., "Method for grouping Unit Cells Using Pattern Maching Technology of Impedance Spectrum," (US. Patent No. 6674287), January 6, 2004

[5] M. K. Hossain and S. M. R. Islam, "Battery Impedance Measurement Using Electrochemical Impedance Spectroscopy Board," 2017 2nd International Conference on Electrical & Electronic Engineering (ICEEE), Rajshahi, 2017, pp. 1-4, doi: 10.1109/CEEE.2017.8412902.

[6] Digilent, Inc., Analog Discovery™ Technical Reference Manual, Copyright Digilent, Inc. Revised March 18, 2015