Variation of the Capacitance of Supercapacitors with Current and Frequency

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Abstract -- **In this work, the charge and discharge cycle of a supercapacitor was examined from which it was observed that the capacitance of the supercapacitor changes while charging and discharging. So also, the capacitance was observed to vary with frequency when frequency response analysis was performed on it.**

Keywords: Supercapacitors, Energy-Density, Charge-Discharge Testing.

I. INTRODUCTION

AS A result of the rapid development in technology and the availability of portable devices, researches on energy storage devices are under process in order to obtain storage devices that have higher energy density as well as higher power density. Batteries have higher energy density but with lower power density. In the case of supercapacitors, the reverse is the case [1]. Thus present researches are on how to improve the energy density of supercapacitors so that it can replace batteries in some applications [2]. The Ragone Plot below shows the various forms of energy storage devices, their energy density and power density.
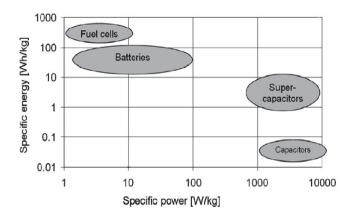

Figure1: Ragone plot of energy storage devices [3].

In order to improve the energy density of supercapacitors, various materials have been developed and some are still in the process. The storage capability of these new materials can only be examined by experimentation. Such experiments could either be cyclic voltammetry, impedance spectroscopy or charge/discharge testing [4], [5]. In this work, impedance spectroscopy and galvanostatic charge/discharge cycling were employed to see the frequency as well current behaviour of supercapacitors.

II. METHODOLOGY

Step I: Galvanostatic Charge/ Discharge cycling was performed on a capacitor, using an Arbin BT2000 multi channel battery testing instrument along with its Arbin MITS Pro Software. The galvanostatic current was set at 50mA. The results below were obtained from the experiment.

The charts above were obtained by exporting the results of the experiment to Microsoft Excel and subsequently plotting the charts. Amongst the columns from the excel file there is

$$\frac{dV}{dt} \tag{1}$$

The current of a capacitor is [6]

$$i = C\frac{dV}{dt} \tag{2}$$

Thus,

$$C = \frac{i}{\frac{dV}{dt}} \tag{3}$$

The value of C was then computed from equation (3) and plotted against the testing time.

Step 2: Impedance spectroscopy was performed on another supercapacitor using a VERSASTAT 3 device for a frequency range of 10 mHz to 10 KHz. The plot of capacitance was obtained.

III. DISCUSSION OF RESULTS

The results from the galvanostatic charge/ discharge showed how the current and voltage in a capacitor are. When one of them rose, the other one also rises and vice versa as shown in figure 2. The charge energy also depended on them as shown in figure 3. The capacitance of the supercapacitor was observed to also change during the charging and discharging periods. It increased while charging and decreased while discharging. This is not in conformity with equation 3 in which the capacitance is considered to be constant.
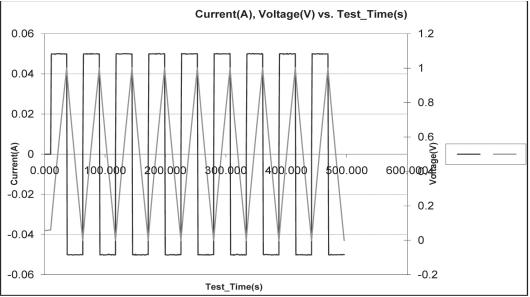
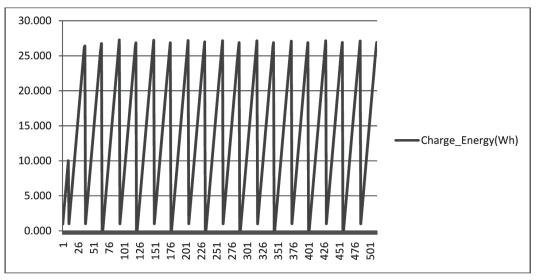Figure 2. Plot of current and voltage vs testing time.

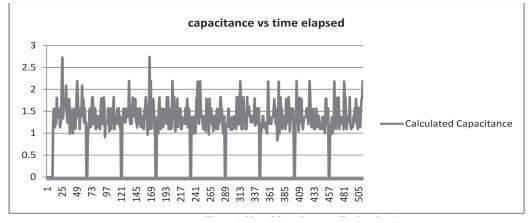Figure 3. Plot of Charging Energy vs Testing time(s).

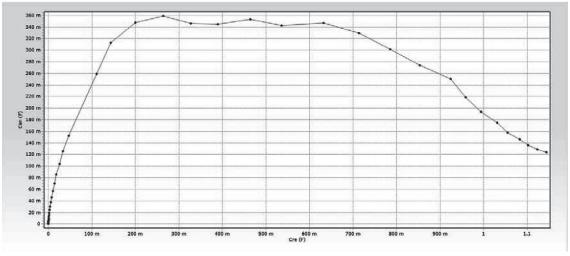Figure 4. Plot of Capacitance vs Testing time(s).

Figure 5. Plot showing the variation of capacitance with frequency.

So also the result from impedance spectroscopy showed how the capacitance varied with frequency. This implies that the capacitance value is not constant but it varies with any of the parameters voltage, current and frequency. As such manufacturers of such kinds of capacitors now include plots in their datasheets so that users can be able to make proper choices.

IV. CONCLUSION

In this paper it has been shown that current, voltage and frequency affect the value of the capacitance of a supercapacitor. In order for users of such products to make proper choices, manufacturers of supercapacitors include more information in their datasheets regarding this issue.

V. REFERENCES

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