EXPERIMENTAL DETERMINATION OF THE ELECTRIC ENERGY STORED IN ELECTROCHEMICAL CAPACITORS

Ángela Cortés, José Carlos Ferrón, Carolina Hidalgo, Julia Valverde, Fátima Vílchez, José Manuel Rus Manjón[2], Carmen Ponce Pérez[1] & Antonio A. Moya Molina[2]

[1]IES Puerta de Arenas
Avda. De Jaén, s/n
23130 Campillo de Arenas (Jaén), SPAIN
ponceorce@gmail.com

[2]Universidad de Jaén
Departamento de Física,
Campus Las Lagunillas, s/n
23071- Jaén, SPAIN
aamoya@ujaen.es

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Electrochemical capacitors, electrical double layer capacitors (EDL) or supercapacitors [1] store electric charge and energy in the electric double layers at the electrolyte-electrode interface. These devices show much higher specific energy than conventional capacitors due to high surface area of activated carbon electrodes. Electrochemical capacitors are typically characterized, by analogy to conventional capacitors, by their capacitance, which is defined as the ratio of the electric charge stored to the electric voltage. Nowadays, there is a growing interest in these devices due not only to their high specific power but also to the rapid charge-discharge capability and the long cycle life. They have already replaced rechargeable batteries in some specialized applications where pulse power is an important factor such, so the optimization of the design of this kind of capacitors is an interesting current research area.

Electrochemical capacitors exhibit several problems such as open circuit voltage decay, capacitance loss at high frequencies or significant variations of the measured capacitance depending on the measurement technique, which limit the performance of working devices. Accordingly, electrical characterization of supercapacitors is a classic researching topic in the field of the renewable power sources. In recent years, various different experimental techniques have been used to characterize electrochemical capacitors such as linear sweep voltammetry, cyclic voltammetry, galvanostatic charging-discharging, potentiostatic charging-discharging through a resistor or electrochemical impedance spectroscopy. In order to evaluate the capacitance of an supercapacitor to energy storage, the potentiostatic charge and discharge processes through a load resistor of known resistance are the two methods most commonly employed.

In this work, we investigate the effect, during the discharge process through a resistor, of the initial voltage on the electric charge stored in four commercial supercapacitors from Cooper Bussman® with the nominal capacitances 0.47, 1, 1.5 and 2.5 F. First, the time evolution of the open circuit voltages after the charging of the supercapacitors at 5 V has been monitored during thirty minutes in order to evaluate the quality of the devices. Second, the discharging of the supercapacitors through a load resistor with 20 Ω of resistance has been displayed for the initial voltages 1, 2, 3, 4 and 5 V. The voltages are supplied with a dc power source by Tektronix and the data are gathered by using the low-cost acquisition data system Arduino. Then, the electric current through the supercapacitor is collected every half second, the stored electric charge being the area of this curve. The effect of initial voltage on the value of the electric charge stored in the different EDL capacitors is analyzed and discussed.

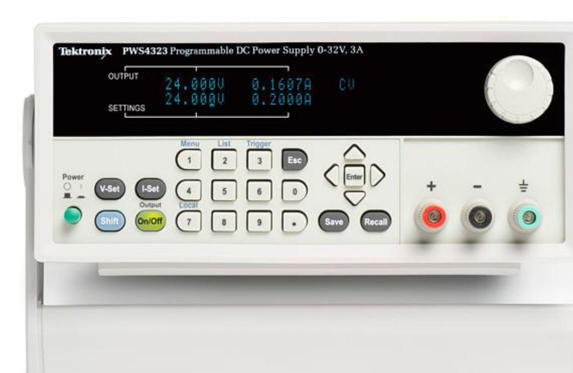
References:

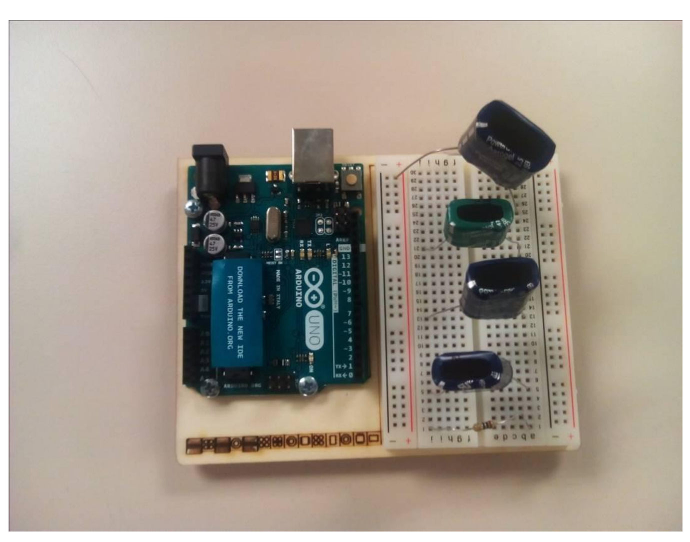
[1] B. Conway, Electrochemical supercapacitors, Kluwer Academic-Plenum Publishers, London, 1999.

MATERIALS AND METHODS

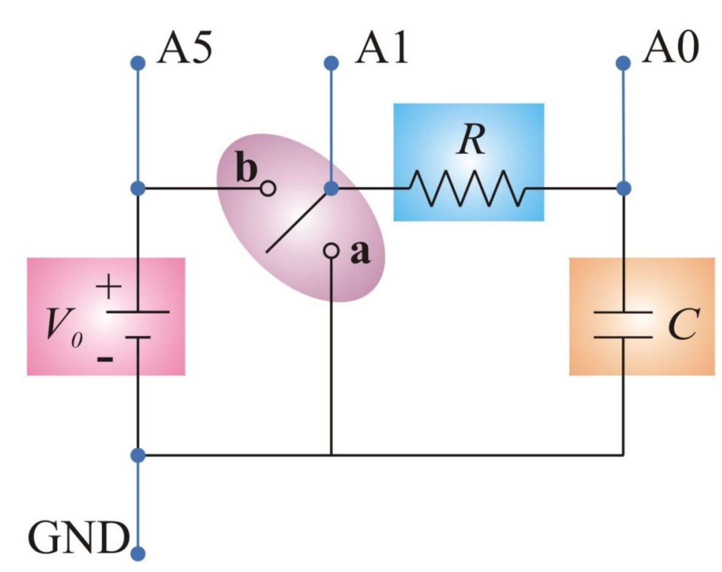
	Reference	*Manufacturer*	R_S (mΩ)	C_{nom} (F)	V_{max} (V)	*Q (mA·h)*
C1	PHV-5R4V74-R	Cooper B.	400	0.47	5.0	0.65
C2	PB-5R0V105-R	Cooper B.	500	1	5.0	1.39
C3	PHB-5R0V155-R	Cooper B.	330	1.5	5.0	2.08
C4	PHB-5R0V255-R	Cooper B.	200	2.5	5.0	3.47

Tektronix Power Supply PWS-2000

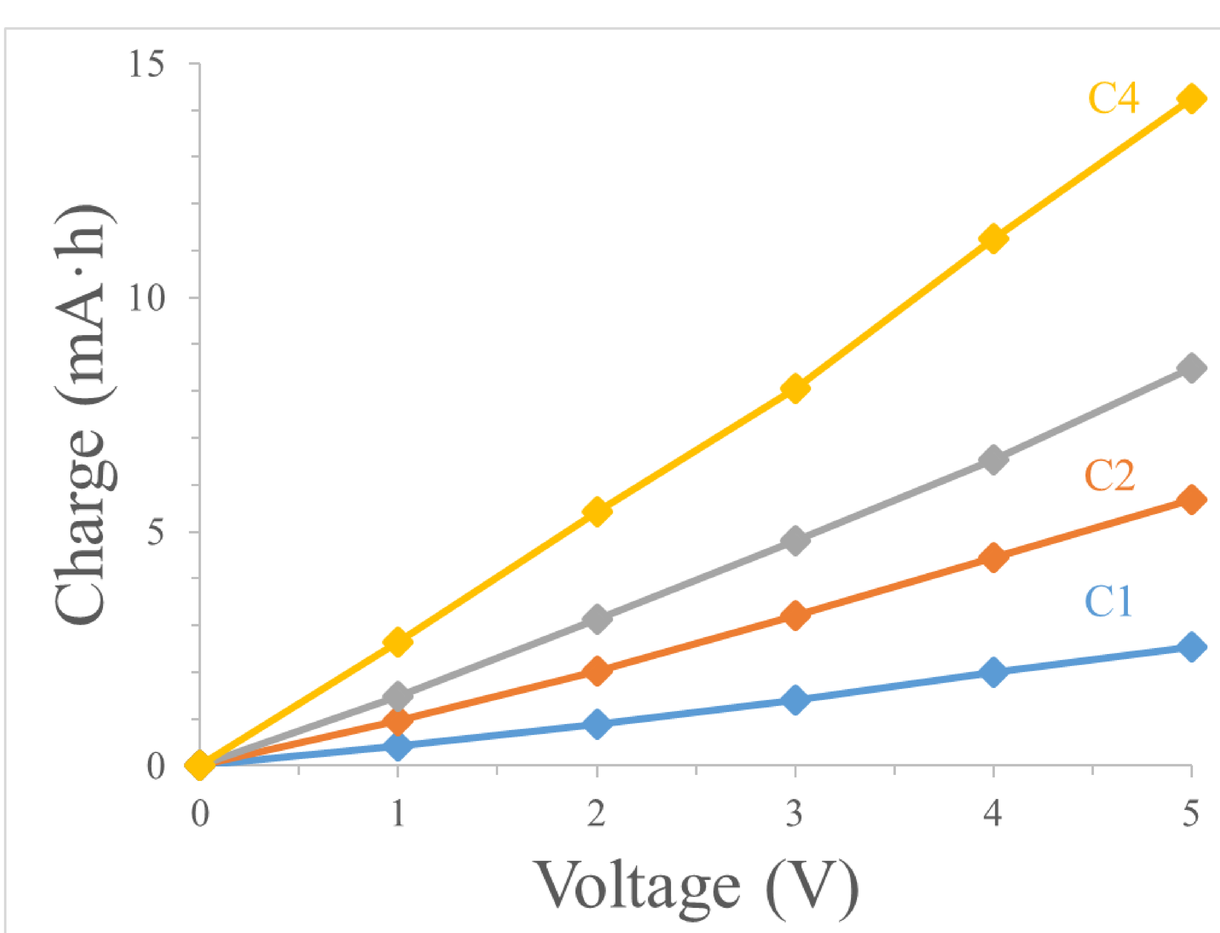




Arduino UNO board and the four EDL capacitors

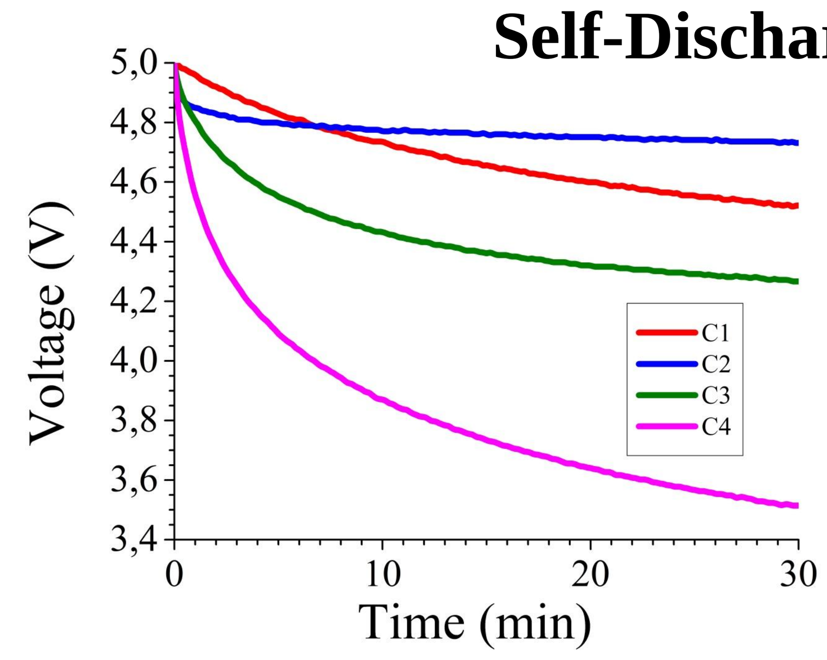


Scheme of the circuit used to do the experiments

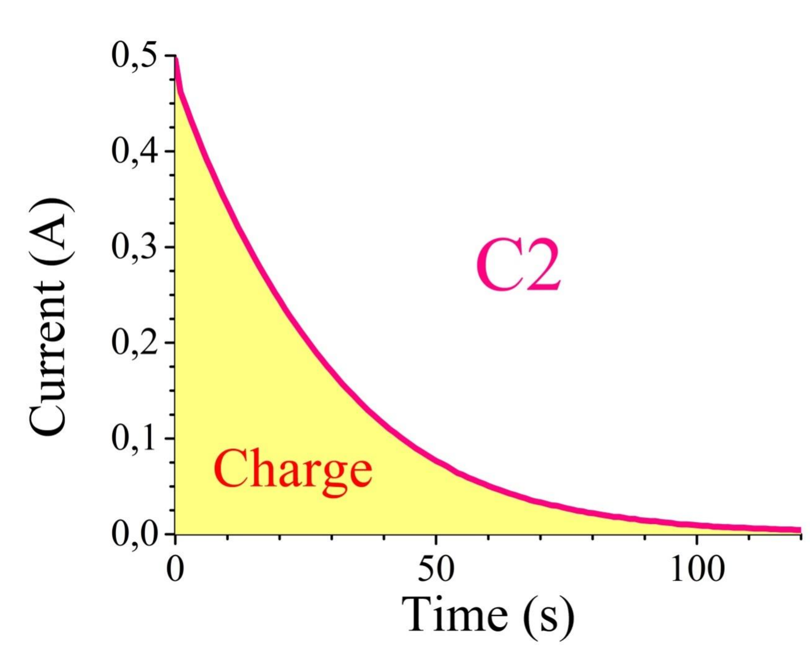


Room Temperature 22 ºC
Atmospheric pressure 972 hPa=0,96 atm

Self-Discharging



Discharging through a resistor



	C1	C2	C3	C4
V_0 (V)	Q_1 (mA·h)	Q_2 (mA·h)	Q_3 (mA·h)	Q_4 (mA·h)
1.0	**0.43**	**0.96**	**1.47**	**2.65**
2.0	**0.89**	**2.03**	**3.12**	**5.42**
3.0	**1.44**	**3.21**	**4.81**	**8.05**
4.0	**1.99**	**4.45**	**6.53**	**11.26**
5.0	**2.54**	**5.69**	**8.49**	**14.26**

CONCLUSIONS

- The charge stored in supercapacitors as determined from discharge processes strongly varies with the electric potential.
- The value of the electric charge increases as the initial voltage increases.
- The slope of the charging curve increases as the voltage increases.

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