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ULISES: AUTONOMOUS MOBILE ROBOT USING ULTRACAPACITORS-STORAGE ENERGY SYSTEM.

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Abstract. Recent technology improvements enabled ultracapacitors (UCaps) to be an interesting option for short-term power applications, such as in industry, automotive and traction drives, regenerative energy system, telecommunication and medical equipment. UCaps are being developed as an alternative to pulse batteries. To be an attractive alternative, ultracapacitors must have at least one order of magnitude higher power and a much longer shelf and cycle life than batteries. UCaps have much lower energy density than batteries and their low energy density is, in most cases, the factor that determines the feasibility of their use in a particular power application. The main advantages of UCaps are that they can provide high power capability (60-120s is typical), excellent reversibility (90-95% or higher) and long cycle life (>10^5 cycles). Thus they exhibit 20-200times larger capacitance per unit volume or mass than conventional capacitors. In this paper, an autonomous mobile robot was converted from a conventional lead-acid or lithium-ion battery to an ultracapacitors as the power source. The integration of UCaps as element of energy storage on the robot was studied with the main of optimizing the energetic solution. The design of the ultracapacitors based power supply system is outlined.

Keywords.
Ultracapacitor, electrochemical double-layer capacitors EDLC, mobile robots, energy/power density, capacitive energy-storage.

1. State of the Art.

Ultracapacitors (UCaps), also known under colloquial names such as Electrochemical Double-Layer Capacitors (EDLC), power capacitors or supercapacitors, are energy storage devices with high power capability and long life. UCaps achieve capacitances several orders of magnitude larger than conventional capacitors. So referring these capacitors as electrochemical capacitors ECs is more appropriate, which is similar to a battery, they both require two electrodes (anode and cathode), an electrolyte and a conducting charge path in order to operate -see figure 1-. ECs also have an additional component, the separator that electrical isolates the two electrodes. Electrochemical capacitors have been known since many years (first patents date back to 1957, Becker U.S. Patent 2 800 616 to General Electric). Today several companies such as Maxwell Technologies, Panasonic, EPCOS, NEC, NESS and several others invest in electrochemical capacitors development. The beneficial characteristics of ultracapacitors are possible due to their composition and construction. Actually UCaps are available in sizes up to 10000F per unit today with typical voltage ratings of up 2,3-2,7V per cell using carbon activated. Cell voltages up to 3,5V/cell have been reported with structured carbon using ionic liquid electrolyte. Desirable characteristics for use in low power applications include: fast charge, wide operating temperature ranges, low weight, flexible packaging, zero maintenance, long life and environmental friendliness [1, 2].

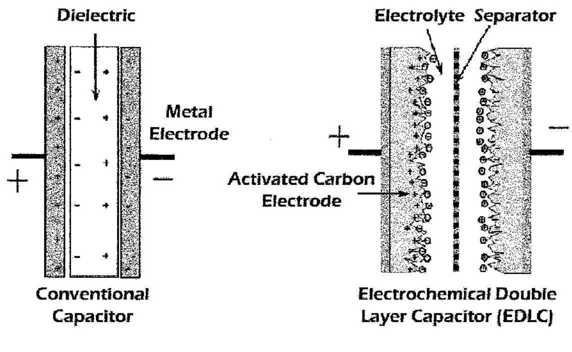

Figure 1. *Structure of aluminium electrolytic capacitors versus ultracapacitor EDLC.*

Conventional capacitors consist of two conducting electrodes separated by an insulating dielectric material, see figure 1. The surfaces on each electrode accumulate opposite charges when a voltage is applied to a capacitor. The dielectric keeps the charges separate producing an electric field. Thus allows the capacitor to store energy. Capacitance "C" is directly proportional to the surface area "A" of each electrode and inversely proportional to the distance "d" between the electrodes. The dielectric constant of free space is ε_o ($8,85\times10^{-12}$ Farads/meter) and ε_r is the dielectric constant of the insulating material -dielectric- between the electrodes [3].

$$C = \varepsilon_o \varepsilon_r \frac{A}{d} \qquad E_C = \frac{1}{2} C V^2 \qquad (1)$$