Control Strategy for Power Generation from a Capacitive Mixing Cell and Grid Injection

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Abstract

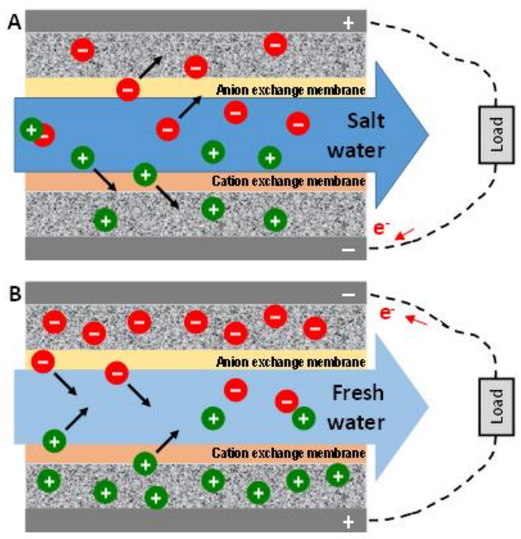
This work investigates the possibility of extracting energy from a capacitive mixing cell using the salinity gradient between fresh and salt water passing through the electrodes of a deionization cell. The process is divided into two stages: the first uses a dual buck-boost converter for the positive and negative input voltage cycles. The second stage is made up of an H-bridge inverter that is synchronized with the AC grid and feeds power into it. A hysteresis system controls the current flowing through the inductor. It was investigated how changes in the CapMix cell's series resistance or the inductor discharge current affect system efficiency. Simulations with PLECS are used to characterize energy extraction, and some experimental results confirm the possibility of using this new renewable energy source, with a maximum achievable efficiency of 70%.

Keywords -CapMix cell, power factor correction (PFC), salinity gradient, hysteresis control.

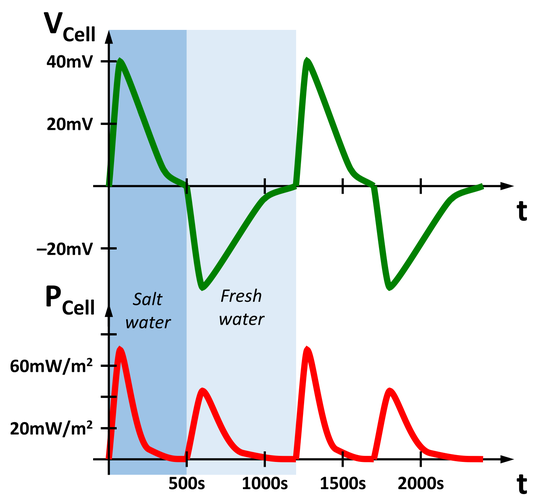
Background and Motivation

- Increasing impact of global warming from greenhouse gases and need to limit it.
  - ❖ Solution is renewable energy systems (solar, wind, hydroelectric, biomass, ocean energy).
  - ❖ Use of ***Blue Energy*** is another solution (RED, PRO, CapMix)
- Two major challenges for harnessing blue energy
  - Finding suitable locations
  - Developing appropriate strategies for converting it into useful form

Functioning Principle of CapMix Cell

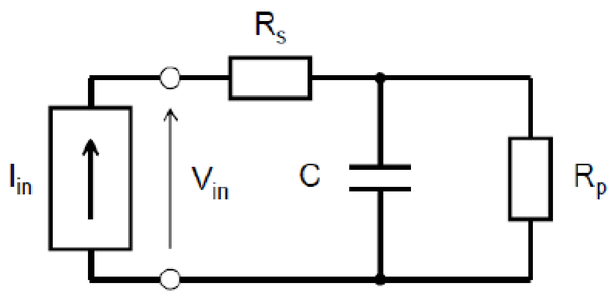


(A) Charging process of the cell in sea water (B) Discharging process of the cell in river water

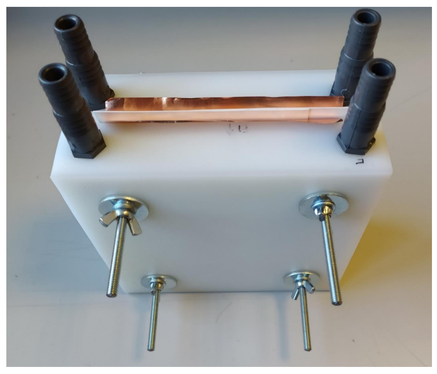


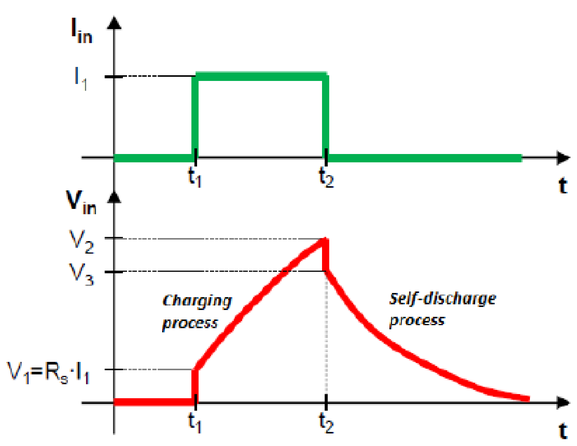
Voltage and power production in a CDP CapMix cell

CapMix Cell Characterization



The cell behaves like a supercapacitor

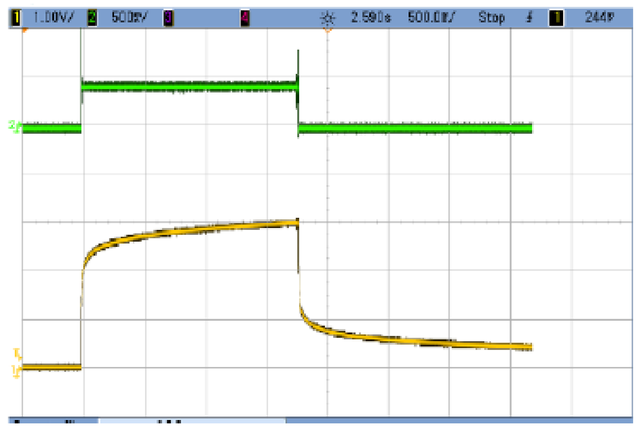




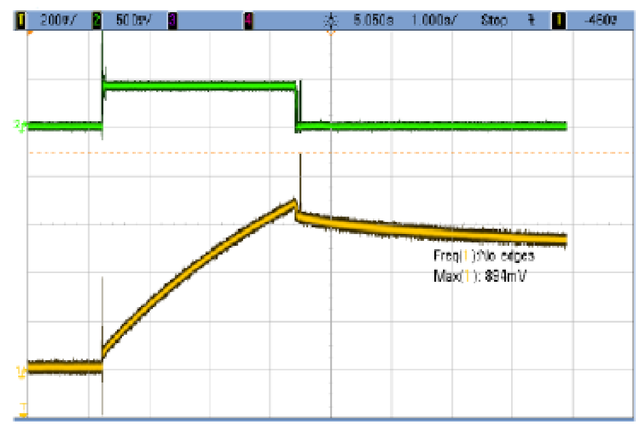
$$V_2 - V_1 \approx \frac{I_{in}}{C}(t_2 - t_1)$$

$$V_{in} \approx V_3 e^{\left[-\left(\frac{t-t_2}{R_p C}\right)\right]}$$

$$R_p = -\frac{t_{p1} - t_{p2}}{C \ln\left(\frac{V_{p1}}{V_{p2}}\right)}$$

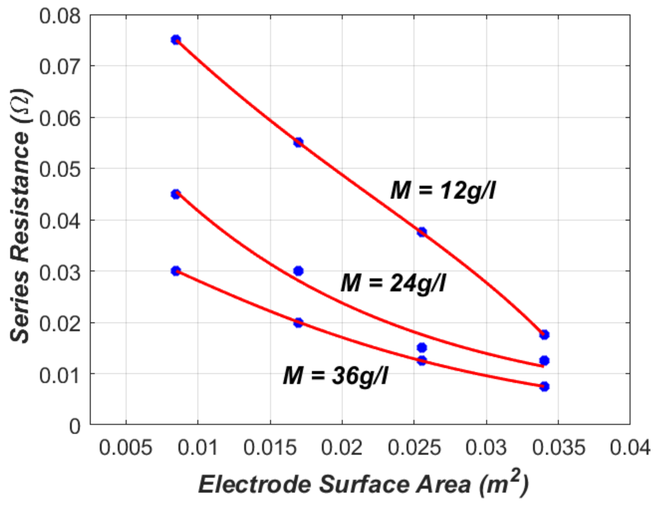


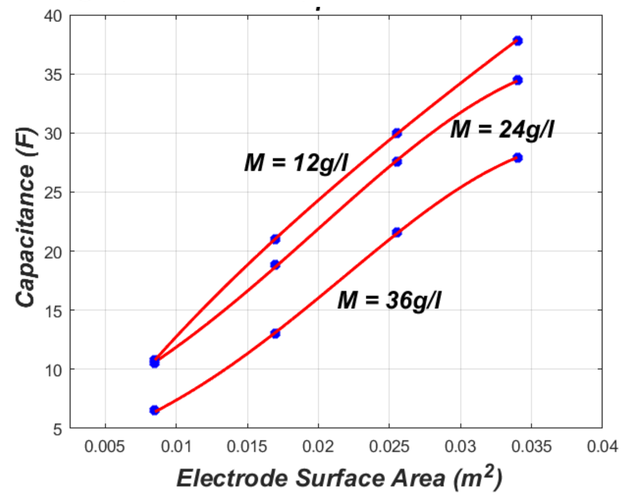
(A)



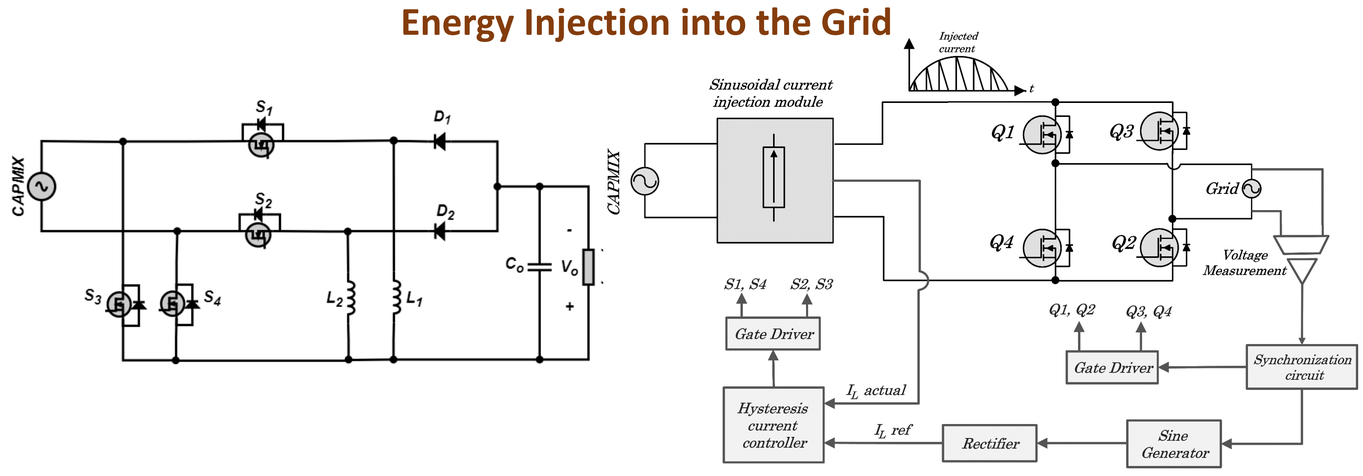
(B)

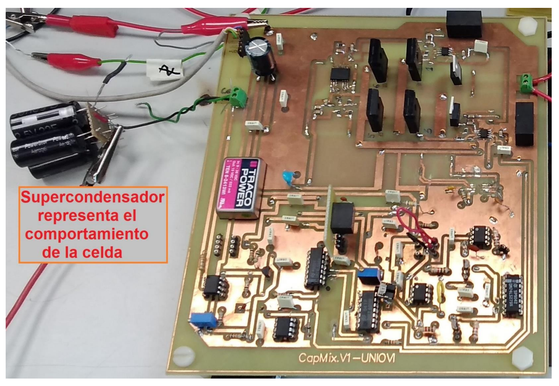
Sample experimental charge-discharge profile of CapMix cell

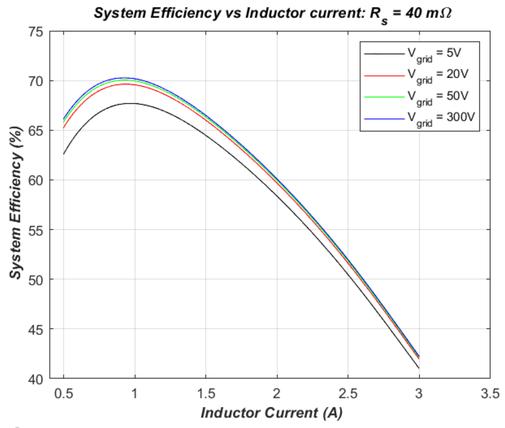




Energy Injection into the Grid

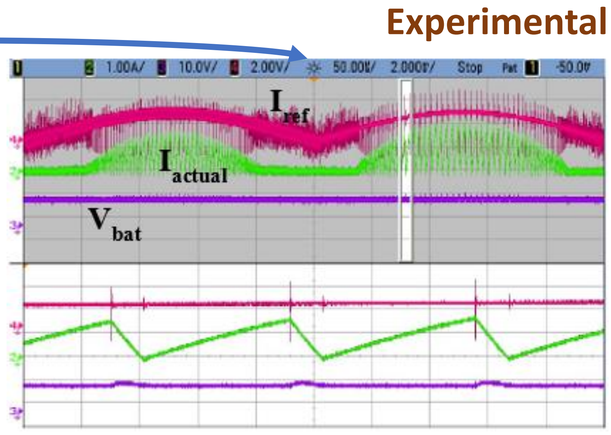


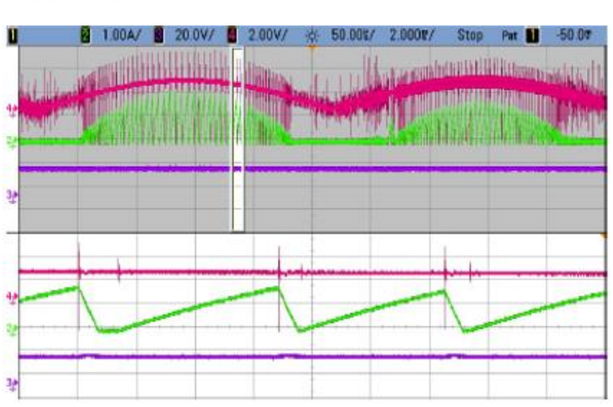


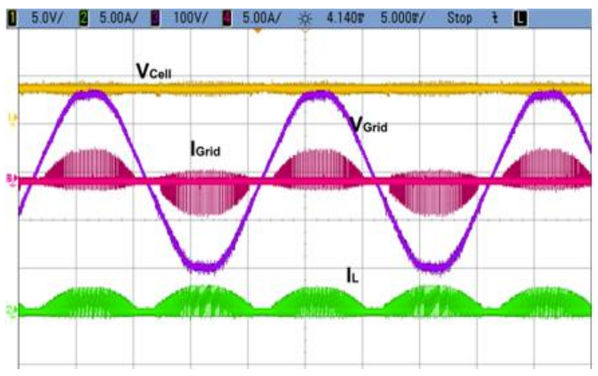


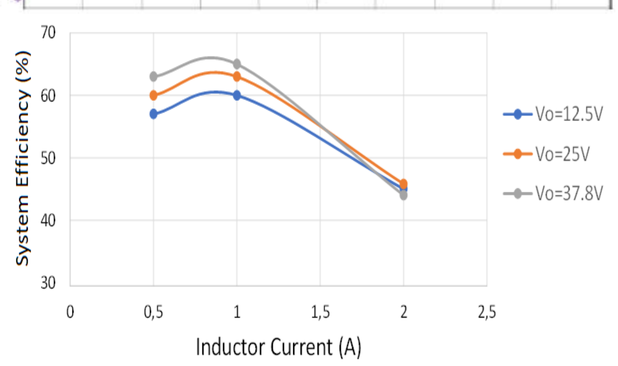
Energy injection to DC grid

Experimental Results









Conclusion

We have seen the possibility of injecting energy to the grid from a CapMix cell with the chosen topology able to implement power factor correction. The cell characteristics, especially its electrode, still needs to be improved and is under research.